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Perception of Body Position and of the Position of the Visual Field

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TABLE OF CONTENTS

PERCEPTION OF BODY POSITION AND OF THE POSITION OF THE VISUAL FIELD*

I. INTRODUCTION

IN PREVIOUSLY reported experiments (1, 2, 5, 6) a common technique was employed to establish the position of the individual's perceived upright under any given condition. He was required to adjust a rod to what he believed to be the true vertical and horizontal. This procedure permitted a study of one of the frequently encountered situations in which perception of the upright is involved; namely, where there is a need for determining the direction of an item that forms part of a larger field, or that is presented in isolation. There are other circumstances, however, in which an estimate of the upright must be made. Frequently the position of the body itself or of the whole visual field, in relation to the true vertical and horizontal, must be determined. These aspects of orientation, which are very important, cannot be studied directly by means of the rod-adjustment technique.

There were certain additional limitations to this technique, as used in previous studies. First, it involved the special difficulty that some disturbance may have been experienced when the rod was out of line with, or did not "fit," its surroundings. The possible compulsion to make the rod look "proper" in relation to the field may in some instances have complicated the real task of adjusting the rod to the upright. Second, the rod-adjustment technique was also rather static. While provision was made for tilting both the visual field and the body, it was not generally possible to obtain judgments while these changes were going on. This was a serious limitation, for spatial adjustments are typically characterized by changing relations between the individual and his field. Third, it involved a relation between the individual and his surroundings which was much more remote than that which normally exists. Whereas ordinarily the person is a part of the visual field, in these situations he viewed the field from a distance. This made the field something akin to a painting on the wall.

To investigate the manner in which the position of the body and the position of the field as a whole are perceived, and to overcome some of the difficulties inherent in the rod-adjustment technique, a fundamentally new procedure was developed for the study to be reported here. The *S* was placed within a room, which could be tilted about him to left or right. Provision was also made for tilting the *S* himself to left or right, while the room was either upright or tilted. With this device it was possible to displace the entire visual field, which the *S* might then be required to return to the upright, and to do the same with the body. By providing for adjustment of the body, this technique, in contrast to the rod-adjustment technique, made possible a direct study of the factors involved in perception of body position. By permitting manipulation of the whole field,

* The experiments herein reported were performed in 1943-44 while the writer was a Fellow of the National Research Council. Grateful acknowledgement is due to the late Professor Max Wertheimer and to Professor W. Köhler, who served as sponsors of the fellowship. A grant from the Committee on Selection and Training of Aircraft Pilots of the National Research Council, which provided funds for construction of the apparatus used here, is also gratefully acknowledged. Finally, appreciation is due to D. Dinnerstein, who served as assistant in the experiments described in Parts A and B of Section III.

this technique made possible a study of the manner in which the position of the field itself is determined. The new technique also provided a more dynamic situation, in that there was the possibility of rapid and continuous change in the positions of body and field. Further, the possible "esthetic" interest in having the item adjusted to "fit" its surroundings was eliminated when the field as a whole was manipulated. Finally, the new device made it possible to place the person within the field, rather than requiring him to view it from a distance.

With this new apparatus[1] a study was made of the way in which one's own position in space is determined. Also, additional experiments were performed on judgment of the upright "out there." Finally, a study of orientation during changing relations between body and field was carried out.

[1] The tilting-room-tilting-chair apparatus employed resembled that used by Kleint (4) in some of his orientation studies. Kleint had a chair within a room, which could be tilted together or independently of each other. He had *Ss* indicate the upright by adjusting a rod in the room, however, rather than by adjusting the room itself or the body, as was done here. Kleint's situation was therefore more nearly like the rod-adjustment situations of our earlier experiments. Another difference is that Kleint's apparatus provided for front-back tilts, rather than left-right tilts.

II. THE APPARATUS

THE tilting-room-tilting-chair apparatus used here is shown in Fig. 1. The room of the apparatus was 6 feet long by 5 feet wide by 5 feet high, and constructed of plywood. It lacked a back wall, permitting *E* to see into it and to speak to the *S* during the experiment. Pivoted at its front center and back center, on stands rising from the floor, this room could tilt to left and right about its front-back axis. A worm-gear arrangement, mounted at the rear pivot of the room, made it possible for *E* to tilt the room simply by turning a crank. A maximum displacement of 35° to either side was possible. To determine the degree of tilt of the room, a protractor, which moved with the room against a stationary pointer, was used. This protractor was located at the rear of the apparatus, where it could easily be read by *E*.

A two-foot, twenty-five-watt fluorescent lamp mounted at the top of the front wall of the room provided internal lighting. At the same time the laboratory was kept fairly dark, to eliminate shadows from stationary objects on the outside, which might cue the *S*. The interior of the room was painted gray, and its borders were accentuated with white strips to provide a well-defined visual framework. For this same purpose, two pictures in rectangular frames were mounted on the front wall.

The chair, which was located in the middle of this room, was built with a high back and was provided with arm rests, headrest, and footrest. It also had side supports which ran from front to back to a height of 9½ inches from the seat; and which protruded 6 inches from the back, from this point to the top of the chair. The lower broad part of the side supports also provided arm rests. These side structures served to support the body when the chair was tilted. The back, seat, and lower portions of the sides of the chair were padded. This chair was mounted on a shaft, which projected into the room through its rear opening from a stand at the back of the apparatus. The chair unit was thus completely independent of the room. Again, a worm-gear arrangement mounted at the end of the shaft enabled *E* to tilt the chair to left or right. The crank used in this operation was located at the rear of the apparatus, adjacent to the one employed in tilting the room. Like the room, the chair could be tilted by a maximum of 35° to either side, and a protractor system indicated the degree of its tilt.

In brief, this apparatus permitted *E* to displace body and field to left or right, by any amount up to 35°. Each could be tilted independently of the other, or both could be tilted together. In the latter case, the displacement could be to the same side or to opposite sides of the upright. Further, it was possible to vary the speed of movement of each by cranking slowly or rapidly. The apparatus operated with practically no noise.

Not only could *E* tilt the room and chair, but also, by means of duplicate worm-gear systems, the *S* while seated in the chair could carry out the same operations. On a post, rising vertically from the footrest of the chair between the *S*'s legs, were mounted two wheels. By turning the upper of these, the *S* could tilt the chair, and by turning the lower one he could tilt the room. In each case the direction of tilt corre-

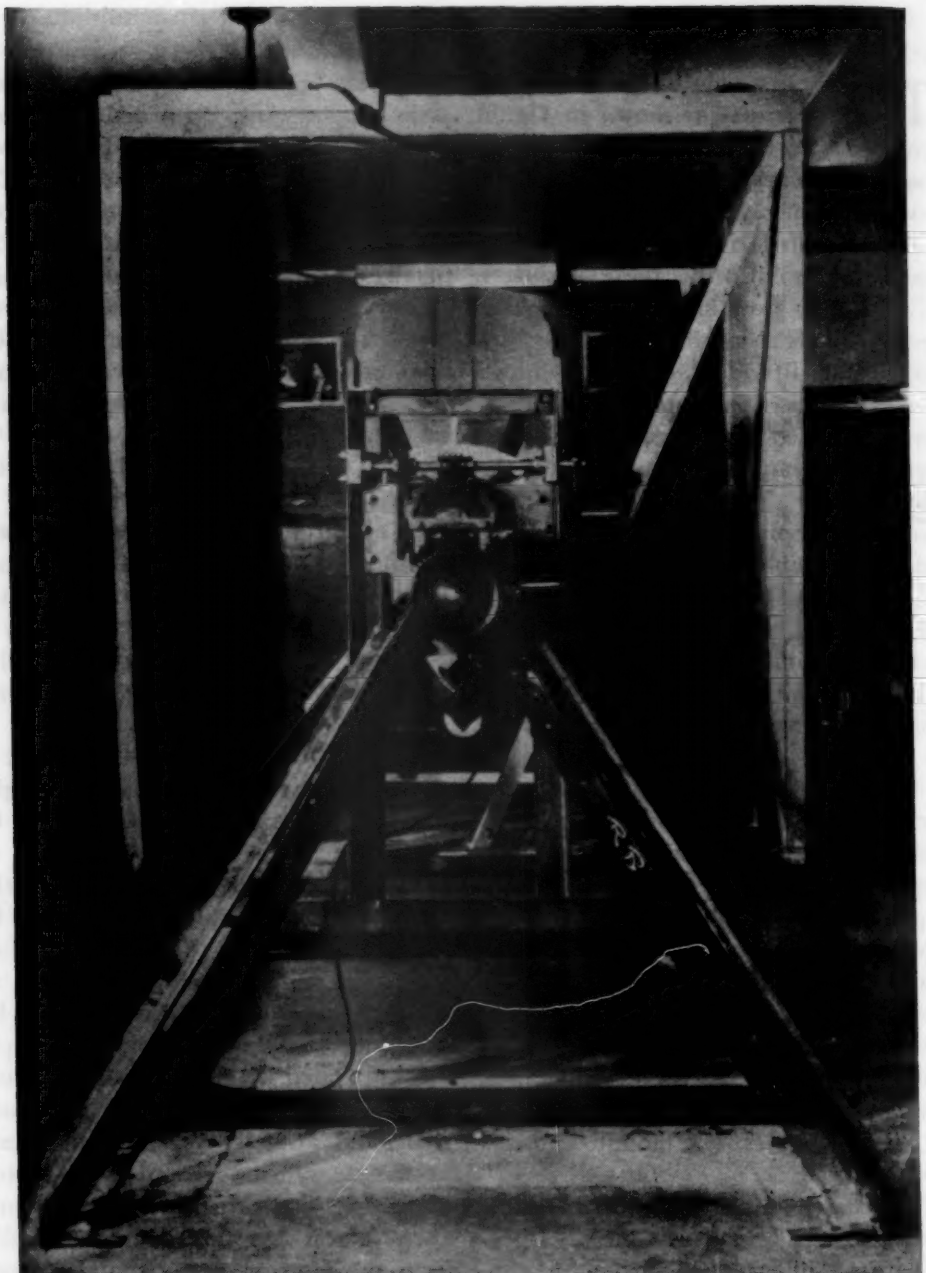


FIG. 1. The tilting-room-tilting-chair apparatus.

sponded to the direction of rotation of the wheel. The inner controls made it possible for the *E* to tilt the body and the room and then require the *S* to return them to what he believed to be the upright.

III. THE EXPERIMENTS

A. Orientation during Changing Relations between Body and Field

In the course of another experiment, to be described in Section IIIG (pp. 34-37), an opportunity was provided to investigate perception of body position and perception of the external upright during continuous movement of the field alone, the body alone, and both together. A repetitive to-and-fro movement from left to right, at a rate of about 3.5° per second, was used in moving the chair and the room. The following six patterns of room-chair movement were employed (the values in each case representing the magnitude of tilt to left and right of the upright): (1) the chair 10°, eyes closed; (2) chair 10°, room stationary; (3) chair stationary, room 10°; (4) chair stationary, room 35°; (5) chair and room 15°, both moving together; (6) chair and room 15°, moving in opposite directions. The *S* was instructed to keep up a running commentary during each test, describing everything that happened to himself and to the room. If he stopped talking, he was encouraged to continue, after a short while, with the question, "What is happening now?" Results were obtained for 45 *S*s, 12 males and 33 females, all but a few of whom were Brooklyn College students.

It was found, first of all, that if only the chair was moved while the room remained stationary (or while the *S*'s eyes were closed) the situation was always correctly perceived. The converse type of operation—movement of the room with chair stationary—produced serious errors of perception. In particular, there occurred an illusory experience of body movement, and a tendency to underestimate the magnitude of room movement or to perceive no room movement at all. As the relation between body and field changed, owing to movement of the room, either some or all of the change was attributed to movement of the body. When *all* the change was attributed to body movement, the room was perceived as completely stationary, even when it had been moved through an arc of 70°. The direction of the illusory body movement was, of course, opposite to the objective movement of the room. When the change was attributed only *partially* to the body, the *S* did perceive movement in the room, but assigned some of the change to movement of his own body. At such times, the room was perceived as moving in one direction—the one it was actually taking—and the body in the opposite direction. Since part of the objective movement was "taken up" by the body, the perceived speed of room movement was less than its actual rate.

Frequently, during room movement with chair stationary, rhythmical shifts occurred from complete to partial illusory body movement. The manner in which these shifts came about is instructive in indicating the basis of the illusion of movement. As the room passed through the upright in the course of the 35° right—35° left movement, for example, the *S* reported that he alone was moving and that the room was stationary. This continued until the room reached its point of maximum excursion at 35°. At the moment of reversal of movement, the *S* reported that he and the room both were moving, in opposite directions. This partial illusory movement continued until the room reached the upright position, at which time the room again seemed to be stationary and complete illusory body movement took

over. Perception of room movement at the moment of reversal probably occurs because the apparent change in direction of body movement focuses attention on the body. This heightens the awareness that sensations from the body, as for example pressure against the sides of the chair, do not adequately account for the magnitude of its apparent movement.[2] As a result, often in a not fully verbalized way, some of the movement is assigned to the room. As the room continues to move back toward the upright, body experiences receive less attention and visual impressions "take over" once more. In brief, when a change in the situation focuses attention on the body, the illusory movement diminishes; but when the situation continues in a smooth way, visual impressions are predominant and the illusion of body movement is strengthened. A similar shift from complete to partial illusory movement may at times also be accomplished by the adoption of a "body-conscious" attitude.

In another test, the chair was moved as well as the room. They were moved simultaneously but to opposite sides. Here, the illusory body movement was always in the same direction as the real body movement, and was simply added to it, with the result that the body seemed to be moving at a speed greater than its true speed. The increase in apparent speed depended on the extent of acceptance of the field. If the field was fully accepted, and therefore perceived as stationary, the increase in rate of perceived body movement was maximum. If the field was accepted to a lesser extent, so that some room movement was perceived, the increase was not so great.

In still another test, body and field were again moved simultaneously, but in the some direction. Because under these conditions the body, as it moved, always remained in alignment with the field, it did not appear to be tilted in relation to the field. The perceived speed of body movement accordingly tended to be slower than its objective speed. Although diminished in magnitude, some body movement was always perceived because of the mounting pressure against the side of the chair which was experienced as the body was displaced farther to one side.

From the results of the different patterns of movement employed, it is clear that the perceived speed of body movement is a function of the rate of change of the relation between body and field. In some cases a given rate of change will produce the same apparent speed of self-movement, whether the change is caused by movement of the body alone, by movement of the field alone, or by movement of both. The visual framework thus plays a decisive role in the perception of body movement.[3]

Under all test conditions, differences were noted in the extent to which the perception of body position was affected by the visual field. Thus, during room movement with body stationary, body movement was experienced by most *Ss*, and seemed so real that its illusory character was not recognized. Some *Ss*, on the other hand, reported no body movement at all. In some of these cases, movement was experienced but the *S* was able to figure out its illusory basis. In others, the report of no body move-

[2] Because the conflict between visual and postural impressions is increased, many *Ss* become very confused about what is really happening during these periods of reversal.

[3] In this regard the factors governing perception of movement of one's own body are analogous to those governing perception of movement of neutral objects on the outside.

ment actually reflected the absence of any perception of such movement. Similarly, in the situations where the chair was moved as well as the room, some *Ss* were more affected by displacement of the field than were others. Significant individual differences in susceptibility to illusions involving movement of one's own body are thus indicated.

As with many other perceptual illusions, knowledge about the true situation does not eliminate the induced perception of body movement. In some cases, after illusory body movement had been experienced, the *S* was asked to look out the back of the room into the laboratory, to establish that only the room was moving. When he faced the front again, the illusion of body movement typically returned. The intellectual awareness that the room, and not he, was moving did not diminish the impression that the converse was happening.

While the addition of knowledge is generally without effect, changes in the field readily alter perception. For example, when the *S* looked down toward the floor of the room, he was much more likely to experience complete illusory body movement than when he looked toward the ceiling. The former view included parts of his own body, parts of his chair, and the post on which the wheels were mounted, while the latter view consisted almost exclusively of parts of the room. To the extent that illusory body movement results from the changing relation between two visual systems (the body and the surrounding field), it is not surprising that the illusion becomes stronger when one of the systems is added to (as in looking downward) and diminishes when that system is reduced (as in looking upward).

The effect of movement of the field was studied in another way. Instead of being rocked back and forth in continuous fashion, the room was moved in 5° steps, from an initial tilt of 35° right. The *S* remained tilted 22° left, with eyes open. After each movement of the room, he was required to report on its position. It was found that in some extreme cases, where the *S* accepted the field to a marked extent, the room continued to appear straight in almost every position. To help in understanding how this could happen, despite an opportunity to observe each successive change, an account of the performance of an extreme *S* is presented below. Excerpts from her reports at each of the fifteen positions of the room are given.

Room 35° R: "I'm all the way to the left. The room is straight."

30° R: "I think the room is slightly tilted to the left. It was such a slight movement that it was hard to distinguish."

25° R: "Did you move the room then? I wasn't fast enough. I know you moved it but I don't know how. It's straight."

20° R: "The room is definitely going to the left but it doesn't look any different."

15° R: "Now it's slightly tilted to the left. When I see you move it it looks as if it's going to the left, but when I take the whole thing it looks straight."

10° R: "I know you tilted it but it looks straight."

5° R: "That was a very slight move and didn't make any difference. It hasn't changed. I feel sick because of the abnormal position I'm in. I feel sick in the stomach."

0°: "It's straight, but I think you moved my chair also. Oh, you definitely moved my chair from where it was at the beginning." (Actually, the chair had not been moved at all during the entire test. As the room moved, the relation between body and field was changed, affecting the perceived position of the body. The apparent change in body position was used here to explain the change caused by room movement.)

5° L: "The room is still straight. It moved, but it has not changed. I can't understand it. I must be knocked out."

10° L: "That was a big move and it still is straight. No, I think it's slightly to the left. No. This is stupid. It is straight. It depends upon

what light you look at it, what you take into vision. If I look at the whole room, it's straight."

15° L: "The room went to the left." (When asked how the room looked, she replied that it looked straight. When asked whether it really was straight, she said that it was.)

20° L: "Now I understand. You moved the chair, too, to counterbalance it. The pressure on my head is different. It's been constantly lessening." (As the room moved toward the left, the body seemed more in line with the field, so that it looked straighter. This effect was so strong that it even led to the reported diminution in bodily pressures.)

25° L: "I think both I and the room are pretty straight, and maybe slightly to the left, but the room is sraight."

30° L: "We're both straight."

35° L: "The room is definitely going to the left, but it's definitely straight in relation to the outer building."

For this *S* the field seemed to appear about "normal" in each of 15 positions, over a range of 70°. So strong was the effect that contradictory experiences of change in the field were disregarded in one way or another, or simply left unexplained. The effect was also strong enough to induce impressions of change in the position of the body itself.

In another simple test, the *S* held a plumb line in front of him and viewed it while the chair and the room were in various positions. When the chair was tilted and the room upright, all *S*s, without exception, perceived the plumb as hanging straight down. With the room tilted, however, regardless of the position of the body, there occurred the most compelling illusion that the plumb was suspended at an angle—in a direction opposite to the tilt of the room and to an extent corresponding to the room's displacement. So strong was this illusion that only rarely did a *S* even consider the possibility that the free-hanging plumb line, suspended from his own hand, of necessity represented the true vertical. A wide range of alternative explanations was offered to account for the phenomenon. Some *S*s said that a thin, invisible wire was pulling the plumb to one side. Others stated that a strong magnet outside the room was responsible for its displacement. Still others decided that a constant blast of air was being directed at the plumb. Many admitted defeat in the face of so flagrant a violation of the law of gravity, stating that its explanation was beyond them.

To help *S*s understand the basis of this illusion, each was asked to close his eyes, and, while he continued to hold the line in front of him, the room was straightened. Upon opening his eyes, every *S* reported that the plumb was now straight, and almost invariably added that it had actually been moved from its initial tilted position. Here again, even when the *S* was given an understanding of the basis of the illusion, it was not weakened at all.

It is significant, from the standpoint of gauging the importance of bodily factors, that changing the relation of the plumb line to the body is without effect, whereas changing its relation to the visual field radically alters its appearance. Provided the visual field remains erect, it is possible to place the body in any position, and the plumb will continue to appear vertical. If the visual field is tilted, however, even though the body remains erect and continues to provide an adequate basis for judging the upright, the line will appear slanted. Again, as in previous experiments, it is found that displacement of the field from the upright leads to serious consequences, regardless of the position of the body. Conversely, changes in the position of the body, with the field remaining upright, are entirely without effect.

B. Quantitative Tests of Perception of the Position of the Field and the Body

In these experiments the *S* was required to adjust either the room or his body to what he perceived to be the true upright. Such a procedure yields precise quantitative estimates of orientation ability, thereby making possible a comparison of different experimental conditions, as well as a comparison of individual performances under the same conditions.

1. *Procedure*

The procedure consisted of bringing the room and chair to a given position, and then requiring the *S* to straighten the one or the other. Several different initial room-chair relations were employed, in order to provide situations of varying difficulty. On the basis of findings from earlier studies in this series, it was possible to select situations in advance in terms of their probable difficulty. The specific room-chair tilts used, the adjustment required in each case, and the number of trials given were as follows:

Test 1: Chair upright, room 35° left or right. *S* adjusts room. 6 trials.

Test 2: Chair 22° left, room 35° left. *S* adjusts room. 3 trials.

Test 3: Chair 22° left, room 35° right. *S* adjusts room. 3 trials.

Test 4: Chair 22° left, room 35° left. *S* adjusts chair. 3 trials.

Test 5: Chair 22° left, room 35° right. *S* adjusts chair. 3 trials.

Test 6: Chair 22° left, eyes closed. *S* adjusts chair. 6 trials.

The first three tests required adjustment of the field, the last three adjustment of the body. It will be noted that the room had to be straightened while the body was: (*a*) upright (test 1), (*b*) tilted with it (test 2), and (*c*) tilted opposite to it (test 3). The body had to be straightened (*a*) while the room was tilted with it (test 4), (*b*) while the room was tilted opposite to it (test 5), and (*c*) in the absence of a visual field (test 6). Three trials were given in tests 2, 3, 4, and 5, and six trials in tests 1 and 6. In administering this series, the six trials comprising tests 2 and 3 were combined and presented in an alternating sequence; tests 4 and 5 were similarly combined.

The procedure used in presenting each trial was as follows. Chair and room were brought to the required settings while the *S*'s eyes were closed. Upon opening his eyes the *S* was asked to describe both his position and the position of the room. Straightening of the room or chair, whichever was required by the particular trial, was carried out by the *S* himself by turning the appropriate wheel on the shaft before him.[4] On trials in which the room was being adjusted, the chair remained in its initial position throughout; and when the chair was being adjusted the room was left in its initial position.

It may be assumed that the amount by which the room is tilted when perceived as upright provides a measure of the extent of acceptance of the visual framework. A *S* who perceives the room as straight at its initial tilt of 35°, for example, shows a greater acceptance of the field than one who requires that it be moved to 10° before perceiving it as straight. Similarly, in the chair-adjustment tests it may be assumed that the

[4] With a few *Ss*, adjustment of the room or chair was carried out by the *E* at the *S*'s direction.

farther the body is tilted toward the prevailing field when perceived as upright, the greater is the *S*'s dependence on the visual framework in his perception of body position.

Fifty-four *Ss*, 15 males and 39 females, all but a few of whom were Brooklyn college students, were given the first five test conditions.[5] Twenty-three of these were given test 6 as well.

TABLE 1

MEAN ERRORS IN ADJUSTING ROOM AND CHAIR FOR EACH ROOM-CHAIR COMBINATION EMPLOYED

Task	Test No.	N	Initial Positions of Room and Chair		Mean Error
			Chair	Room	
Room Adjust.	1	50	Upright	35° L or 35° R	11.7°
	2	53	22° L	35° L	12.8°
	3	53	22° L	35° R	22.3°
Chair Adjust.	4	47	22° L	35° L	9.4°
	5	48	22° L	35° R	5.9°
	6	23	22° L	(eyes closed)	2.4°

2. *Results*

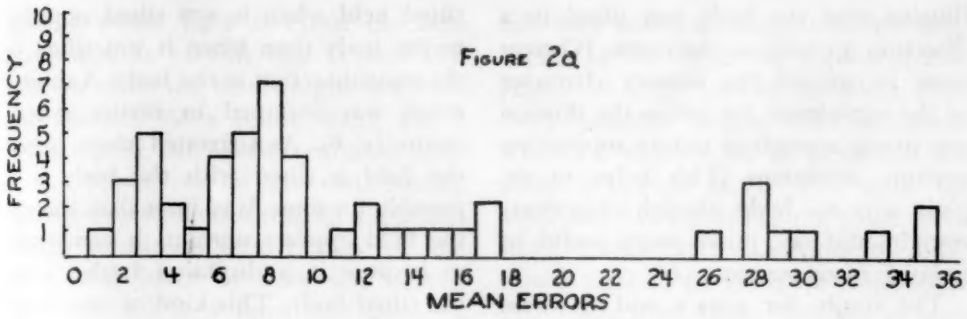
Table 1 presents the mean amounts by which the adjustment of room or chair differed from the true upright under each test condition. These values correspond, then, to the mean errors made. To provide a picture of the individual performances making up these averages, frequency distributions are presented in Fig 2. for the room-adjustment tests and in Fig. 3 for the chair-adjustment tests.

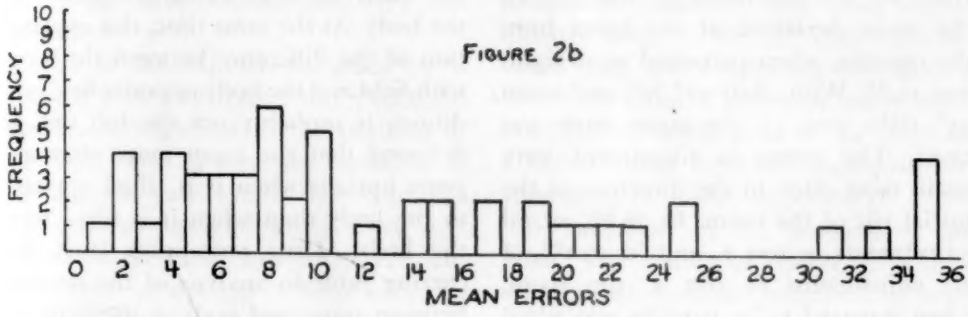
a. Judgment of the position of the field. Considering first the results of test 1, where the body was erect and the room initially tilted 35° left or right, the mean error for all *Ss* together was 11.7°. In other words, the room was tilted by 11.7°, on the average, when perceived as upright. Furthermore, in 90.4% of all adjustments the room was tilted to the side of its initial displacement,[6] indicating an underestimation of its tilt. This reflects a tendency to accept the visual framework in its original tilted position. From Fig. 2a, where a frequency distribution for this condition is presented, it may be seen, however, that there are striking individual differences in the extent to which the framework was accepted. At one extreme is a *S* who was able to bring the room to within an average of one degree of the true upright. At the other extreme are found two *Ss* who on all six trials perceived the room as straight at the very outset, so that their mean error was 35°

Since in this test the *S* sat erect, the task of adjusting the room required simply that it be aligned with the upright body. It is surprising that under these conditions the body did not help bring about a more accurate adjustment of the room. In part, at least, this is because perception of the body itself was affected by the tilted framework, so that in most *Ss* there occurred a strong

[5] In some instances, one or more of the conditions were omitted. Forty-five of these *Ss* also served in the experiment described in Section III G. They received the tests of the present experiment first, however.

[6] In cases where the room was tilted to the opposite side, the errors were extremely small, averaging only 3.3°. In these instances the *S* was making a fairly accurate judgment, but tended to overcompensate somewhat.





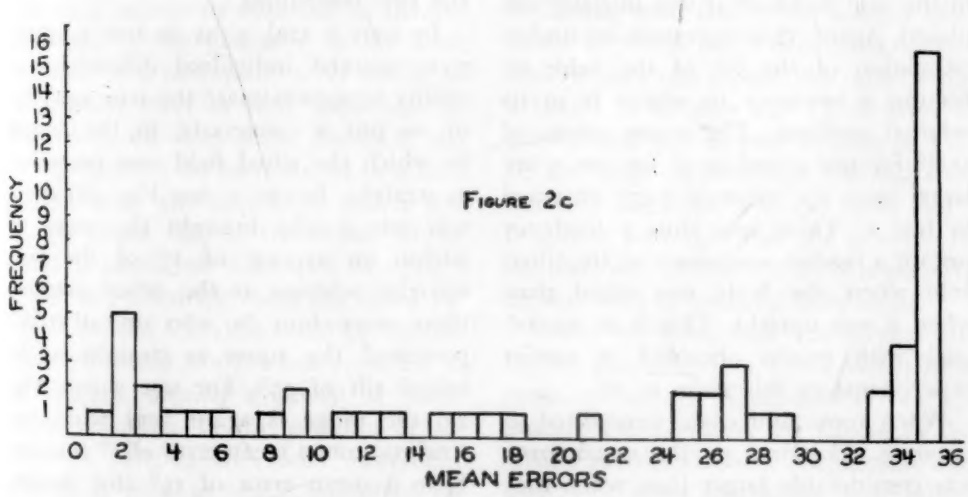


FIG. 2. **Distributions of scores for the room-adjustment tests. Fig. 2a presents results for test 1, where the chair was upright and the room 35° left and right; Fig. 2b for test 2, where the chair was 22° left and the room 35° left; and Fig. 2c for test 3 where the chair was 22° left and the room 35° right. The N is 50 in Fig. 2a, and 53 in Figs. 2b and 2c. The number of trials was six for test 1, and three for tests 2 and 3.**

illusion that the body was tilted in a direction opposite to the room. Whereas some recognized the illusory character of the experience, for others the illusion was strong enough to induce supporting pressure sensations. This helps to explain why the body, though objectively upright, did not prove more useful in judging room position.

The results for tests 2 and 3, where both chair and room were initially tilted, may be considered together. With chair 22° left and room 35° left (test 2), the mean deviation of the room from the upright, when perceived as straight, was 12.8°. With chair 22° left and room 35° right (test 3), the mean error was 22.3°. The errors in adjustment were again most often in the direction of the initial tilt of the room. In 76.8% of all adjustments in test 2, and in 90.1% of all adjustments in test 3, the room, when reported to be straight, was tilted to the side to which it was initially displaced. Again, this represents an underestimation of the tilt of the field, reflecting a tendency to accept it in its original position. The mean errors of 12.8° for test 2 and 22.3° for test 3 are larger than the value of 11.7° obtained in test 1. There was thus a tendency toward a readier acceptance of the tilted field when the body was tilted than when it was upright. This is in accordance with results obtained in earlier experiments in this series (1, 6).

When room and chair were tilted to opposite sides (test 3), the mean error was considerably larger than when they were tilted to the same side (test 2). A consideration of individual performances shows the same result. In test 3, sixteen *Ss* on all trials perceived the room as upright, at its initial 35° tilt, as compared with only four *Ss* in test 2. There was thus a readier acceptance of the tilted field when it was tilted opposite to the body than when it was tilted in the same direction as the body. A similar result was obtained in earlier experiments (1, 6). As suggested there, when the field is tilted with the body it is possible for some *Ss* to infer that, though the field appears upright, it cannot be so because it is displaced farther than the tilted body. This kind of cue, based on intellectual analysis rather than the appearance of things as such, is not possible when the room is tilted opposite to the body. At the same time, this explanation of the difference between the body-with-field and the body-opposite-field conditions is probably not the full one. It is found that the room more often *appears* upright when it is tilted opposite to the body than when it is tilted with the body. Thus perception itself, occurring prior to analysis of the relation between room and body, is different for the two conditions.

In tests 2 and 3, as in test 1, there were marked individual differences in ability to approximate the true upright, or, to put it conversely, in the extent to which the tilted field was perceived as straight. In test 2 (see Fig. 2b) there was one *S* who brought the room to within an average of 1° of the true upright, whereas at the other extreme there were four *Ss* who on all trials perceived the room as straight at its initial tilt of 35°. For test 3 (see Fig. 2c) the range is again very wide, extending from a mean error of 1° (for one *S*) to a mean error of 35° (for sixteen *Ss*).

It will be noted that the distribution curve for test 3 reaches a marked peak at its upper end. This characteristic is actually an artifact resulting from a limitation of the apparatus. Since the room could not be tilted more than 35°,

Ss who would have accepted the field as upright at various tilts beyond this position could not be distinguished from one another. As a result, there was a piling up of the undifferentiated cases at the upper end of the distribution. In later experiments, using an apparatus which permitted greater tilts of the room, this block of cases was broken up. With this new apparatus some *Ss*, in fact, perceived the room as straight at tilts as great as 60°, so that the upper end of the curve was extended very considerably.

Some of the adjustments made by *Ss* who did poorly in tests 2 and 3 reflected inadequate reference to the position of the body. This is seen, for example, in the extreme case where the room was perceived as upright when tilted 35° left while the chair was tilted 22° left. To accept as upright a field which is tilted 13° farther than the tilted body reflects a failure or inability to involve the body in the judgment of the field, not only at a perceptual level but at an intellectual level as well. This was indicated in an even more dramatic way in experiments (to be reported in a later paper) using the apparatus which permitted larger tilts of the room. There, some *Ss* perceived the room as upright at 56° left when the body was tilted 22° left. The field was thus tilted 34° farther than the tilted body when reported to be straight. Similar evidence of inadequate reference to the position of the body in judging the room was found among *Ss* who, in test 3, perceived the room as upright when tilted 35° right, while the chair was 22° left. If the room is accepted as upright in that position, the 57° angle between room and chair must represent the amount of body tilt. Reference to the body would have indicated much less pressure against the side than would accompany such a large degree of tilt. With the apparatus that permitted larger tilts of the room, even more extreme results were obtained. There, a number of *Ss* perceived the room as upright at 56° left, while the chair was 22° right. For the room to be straight under such conditions, the body would have to be tilted 78°, or practically on its side. Again, reference to body pressures would have indicated that the body could not possibly be in a near-horizontal position, and that consequently some of the 78° difference between body and room must be due to a tilt of the room. There were many other examples of adjustment of the room in a manner that reflected inadequate involvement of bodily experiences.

b. Judgment of the position of the body. The results of tests 4, 5, and 6, all of which involved judgment of body position, may be considered together. Beginning with test 6, the control condition in which the *S* had to straighten himself with eyes closed, the mean error is found to be only 2.4°. This error is quite small, and as may be seen in Fig. 3c. the range of scores for individual *Ss* was very restricted, with the mode at 2°. It is thus indicated that the position of the body was established fairly accurately on the basis of postural cues alone.

When the same task was carried out in the presence of a tilted visual field (tests 4 and 5), significant errors appeared. Furthermore, the nature of the errors, as regards both magnitude and direction, were specifically determined by the position of the field. Considering first the results for test 4, where the chair was initially tilted 22° left and the room 35° left, a mean error of 9.4° is found. In other words, the body was tilted, on the average, 9.4° when perceived as upright. Further, in 97.0% of all adjust-

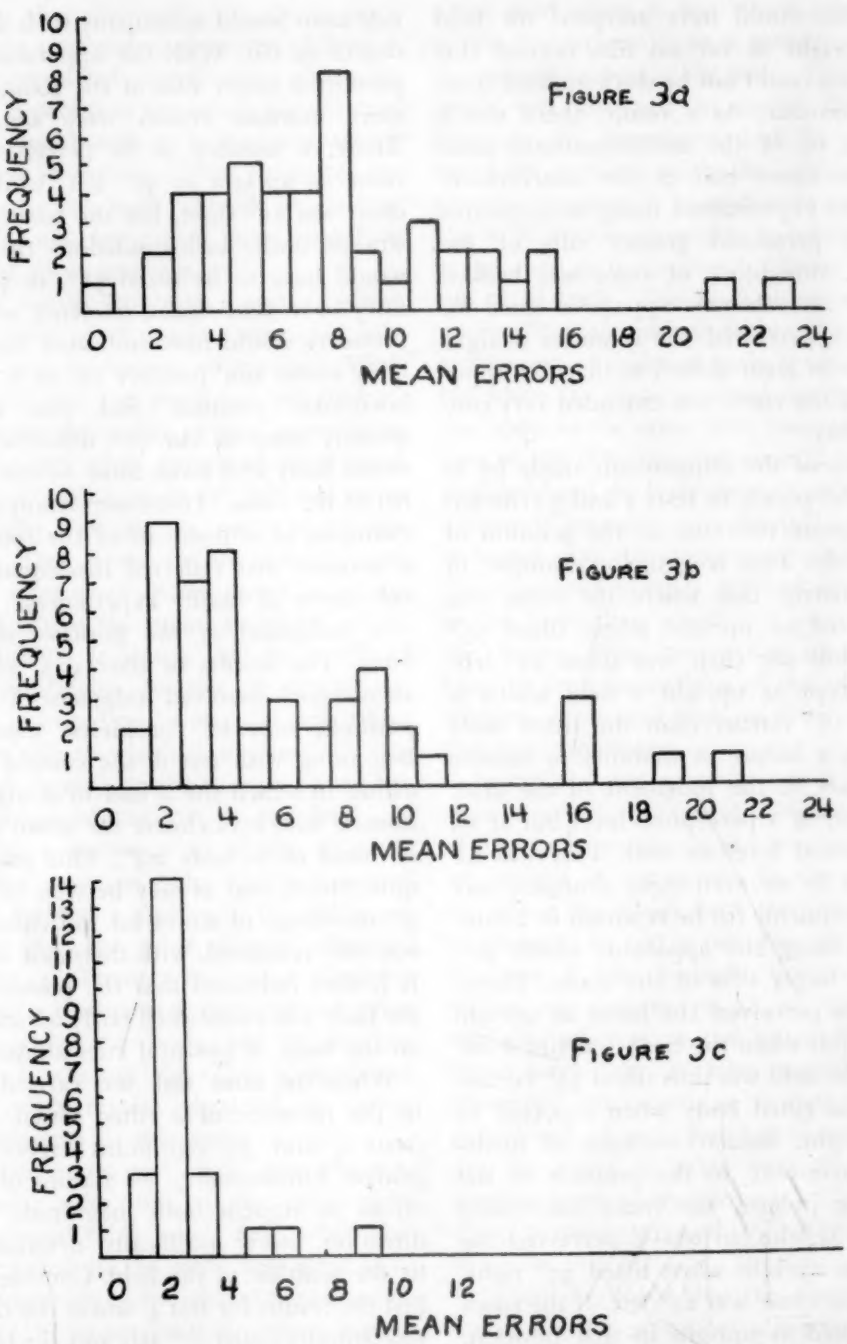


FIG. 3. Distributions of scores for the chair-adjustment tests. Fig. 3a presents results for test 4, where the chair was 22° left and the room 35° left; Fig. 3b for test 5, where the chair was 22° left and the room 35° right; and Fig. 3c for test 6, where the chair was 22° left and adjusted with eyes closed. The N is 47 in Fig. 3a, 48 in Fig. 3b, and 23 in Fig. 3c. The number of trials was three for tests 4 and 5, and six for test 6.

ments it was tilted in the direction of the room—that is, to the left. The fact that the errors were so consistently in the direction of the tilt of the room indicates that the visual basis for judging position is a general one. At the same time, the wide range of individual mean errors for this test, as shown in Fig. 3a, indicates marked differences in the extent to which body position is determined on a visual basis. Some *Ss* were able to bring the body very close to the true upright, despite the tilted field; others, in contrast, were greatly influenced by the field, so that in the five most extreme adjustments, errors as large as 21°, 22°, 23°, 24°, and 31° were found.

For test 5, where the chair was initially tilted 22° left and the room 35° right, the mean error for all *Ss* is 5.9°. With the room now tilted to the right, the errors in making the body upright were most often (in 66.3% of all adjustments) in that direction. As may be seen in Fig. 3b, there is again a wide range of errors, pointing to individual differences in the effect of the field upon judgment of body position. The mean error of 5.9° for this test is considerably smaller than the value of 9.4° for test 4. Further, the body was tilted toward the field in 97.0% of all adjustments in test 4, but in only 66.3% of the adjustments in test 5. It is clear that the judgment of body position was more strongly influenced by the tilted field in test 4 than in test 5. The suggested explanation of the difference is as follows. In test 5, the *S* was initially tilted 22° left and the room 35° right, so that the body not only *felt* tilted to the left but also *looked* tilted to the left. Hence, it was clearly required that the body be moved toward the right to be made straight. In moving the body toward the field, however, there occurred a shift in weight—and therefore in pressure—from the left side to the right side, as the chair passed through the upright position. This shift tended to bring attention to the body, thereby reducing the effect of visual impressions and leading to judgments which were nearer to the true upright. Because no such "body-orienting" experiences occurred in test 4, visual impressions could more readily take over, resulting in larger errors.[7]

Another factor which may have contributed to the difference in results between tests 4 and 5 is the negative after-effect that occurs whenever the body is tilted. It has been found that when the body is tilted to one side, and then returned to the upright, there occurs the experience of being tilted to the opposite side. Hence, to feel straight, the body must be displaced toward the side of initial tilt. This effect is not very strong, as shown by the finding in a separate test given to a group of 11 *Ss*, that the body was tilted by an average of only 1.6° from the upright in compensation for the after-effect.[8] To the extent that it was a factor in the present experiments, however, it complemented the influence of the field in test 4, and worked against the field in test 5. Specifically, in test 4, where the field was tilted with the body, responding to the field involved leaving the body on the

[7] It was found that the chair was more often brought to the true upright in test 5 than in test 4. This also contributed to the smaller percentage of adjustments in the direction of the field in test 5.

[8] With these *Ss*, the chair was tilted to one side and then returned to the upright. If the *S* did not feel straight, he was permitted to move himself until he did. In test 6 of the present experiment the *S* was simply tilted to one side, and required to return himself to the upright from that position.

side to which it was initially tilted; and the negative after-effect produced the same result. In test 5, on the other hand, where the field was initially tilted to the other side from the body, responding to the field involved moving the body to the other side, in the direction opposite to that required by the negative after-effect.

One of the most dramatic experiences encountered in this research occurred in an early experiment with the test 4 type of condition when a *S*, who was tilted 22° left while the room was tilted 35° left, reported that she was tilted to the *right*. In an effort to become straight, she moved herself farther to the left—that is, to an objectively more tilted position. Since that first occasion, this kind of performance has been given by a number of *S*s. Such paradoxical behavior has a simple basis. Since the room was tilted farther to the left than the chair, the body—*in relation to the field*—appeared tilted to the right, and was so judged by *S*s who used the visual field as the primary basis for perceiving body position. *S*s who performed in this fashion also tended to perceive the 35°-left room as fully upright or only slightly tilted. If the room is perceived as about upright, the visual impression that the body is tilted to the right is of course even more compelling. The wrong estimate of direction of self-tilt is thus an expression of extreme dependence upon the visual field, as manifested in a tendency to perceive a tilted field as "proper," and to judge bodily position primarily in relation to the field.

Whenever the body was perceived as upright while in a markedly tilted position, there was the problem of interpreting the failure to experience or take proper account of pressure sensations against the side to which the body was tilted. Did a person who was tilted 25° when he reported himself to be upright *feel* no pressure; or, if he did feel pressure, how did he deal with it? Our protocols show that with some *S*s there was actually no experience of pressure whatever. In such cases the experience of *appearing* straight was apparently so strong that contradictory pressure sensations were actually "submerged." With other *S*s, some pressure was experienced; but, as one well-trained introspectionist described it, this experience constituted a remote, intellectual awareness, which seemed to have nothing to do with the strong, certain, and immediate experience of being straight. It was, in fact, typically necessary in such cases to elicit a statement about pressure sensations through specific questioning, which suggests that there was not even a full awareness of their presence. These pressures, when noted, were either disregarded or simply rationalized away—either of which was easy, in view of their quality. Some of the explanations offered in rationalizing the pressure experiences were as follows. One *S* thought there was a set of magnets outside the room, or that some other "tricky" mechanism was being used. Another *S*, at a point when his body was 17° left, asked: "Can you move my headpiece? I can see that my body is O.K., but my head is over to one side." Thus the pressures, which were particularly strong in the head region, were attributed to faulty adjustment of the headrest. A third *S* gave an elaborate account of her anatomical disposition at the time, evolving a theory of the dynamics of distribution of bodily parts during tilting which proved to her satisfaction that one could be upright or even tilted to the right

and still feel pressure on the left side.

Finally, there were *Ss* who experienced pressure sensations when they judged themselves to be upright though very tilted, and who did not simply discount them or try to rationalize them away. Rather, after trying for a considerable period to find a normal position, they reported that for unknown reasons they could not feel erect and look erect at the same time—that when they looked erect they felt tilted, and vice versa. In this dilemma, they threw the issue back to the *E* and asked him whether he would prefer that they look straight or feel straight. When it was pointed out to them that a position must exist where the body both felt and looked straight, since this is the usual state of affairs, the typical reply was that the apparatus somehow did not permit it.[9] The position finally settled upon in such cases usually was reached after much movement back and forth, and represented a compromise with which the *S* was frequently not satisfied. Protocols for an *S* who gave such a performance will be presented later.

The results of tests 4, 5, and 6 demonstrate the importance of visual factors in the perception of body position. It is indicated that such perception depends not only on how the body feels, but also on how it looks to the *S* in relation to his surroundings. Just as an upright rod in a tilted field was found to appear tilted opposite to the field, so one's own upright body appears tilted under similar circumstances. In order to be perceived as upright, the rod—or the body—must be moved toward alignment with the field. At the same time, these experiments also demonstrate that there are important differences between persons in the extent to which position is determined on a visual basis. Some people seem to rely primarily on the relation between the body and its surroundings. Contradictory bodily sensations are either completely suppressed or perceived only as remote awarenesses that do not form part of immediate experience. In contrast, there are *Ss* at the other extreme who are less affected by visual impressions and who seem able to make very good use of bodily experiences in judging their position. The ranges in amount of error in adjusting the body to the upright under the influence of the tilted field (from 0° to 31° in test 4 and from 1° to 24° in test 5) reflect the magnitude of individual differences in dependence on the field.

C. Some Qualitative Differences in Performance

Individual differences in performance have thus far been described mainly in terms of magnitude of errors made. Such numerical data, however, present only a limited account of the individual's orientation ability. They cannot, for example, convey the extent to which some *Ss* became "lost" in the small 6 foot by 5 foot by 4 foot box used, or the emotionality that often developed in these "cold" and impersonal perceptual situations. In order to appreciate fully the nature and scope of individual differences in orientation ability, it is necessary to supplement

[9] The instructions used in these experiments advisedly did not distinguish between looking straight and feeling straight, but simply requested the *S* to bring himself to the upright position so that he would be sitting as he normally does. The instructions avoided drawing the distinction, in order to keep the situation as natural as possible. This was necessary if the manner in which the *S* ordinarily integrated visual and postural experiences was to be determined. In experiments to be reported later, instructions were used which called specifically for a position in which no pressure was felt.

numerical results with an account of the difficulties experienced by the *S*, and the quality of his reactions to them. This is especially true of *S*s who did poorly in these tests. For this purpose, a full description of the performances of several very poor *S*s will now be presented.

1. *Subjects with Poor Scores Who Gave Troubled Performances*

To begin with, protocols for several *S*s whose orientation was extremely poor and who also experienced great difficulty in getting their bearings are given.

a. Subject A. In test 1 (chair upright, room alternately 35° left and 35° right; room to be made upright)[10] the *S*'s errors in adjusting the room to the upright on the six trials of the test were 18°, 31°, 32°, 32°, 7°, and 35°. This indicated a fairly ready acceptance of the visual field. On the last trial, for example, she accepted the room as upright at its initial tilt of 35°, and consequently reported her own upright body to be tilted.

She was then given test 2 (room 35° left, chair 22° left; room to be made upright). On the first trial, she was able to adjust the room to within 9° of the true upright. On the second trial, she was off by 32°, and on the third trial she was off by 24°. In test 3, when the room was initially tilted 35° right and the body 22° left, she accepted the room as straight at once on the first trial, and on the next two trials was off by 37°, thus tilting the room 2° beyond its initial tilt. These results again show a tendency to perceive the field as straight, even in very tilted positions.

The *S* was then given tests 4 and 5, in which the task was to make her body upright. On the first trial, when the chair was initially tilted 22° left and the room 35° left, she had herself moved to a point where she was 18° to the right. Then she asked that she be moved to the left. At 15° right she reported that she did not feel straight and that perhaps she should go to the right. At 20° right, she asked to be moved to the left. At 11° left—saying, "I'm passing it"—she asked to be moved to the right. At 9° left she first said that she was still not straight, and then decided that she was more-or-less straight, adding: "The whole room is at an angle and I can't feel straight." Thus the chair was finally adjusted at 9° from the upright in the direction of the field. The decision was reached after much conflict, and was one in which the *S* had very little confidence.

On the second trial of tests 4 and 5, where the chair was initially tilted 22° left and the room 35° right, very severe disorientation developed. First the *S* had herself moved past the upright in the direction of the tilt of the room, until she was tilted 24° right. Then she said: "No, I'm at an angle. There are difficult things to decide. I feel by my weight that I'm thrown to the right. Move me to the left. No, to the right. No, maybe more to the left. No, I wish I could tell you; move me more to the right. That's it." (The difficulty was that when she looked straight in relation to the room she felt tilted, and when she felt straight she looked very tilted.)

At 26° R: "I feel cockeyed. Go to the left. I'm sorry if I sound dumb, but I can't get myself straightened out."

At 24° R: "I'm beginning to be on my head. [Excitedly] Turn me to the right. I've never been on my head before. I'm almost on my head now. No wonder I couldn't tell."

At 31° R: "I don't know whether I'm on my head or not. Oh, no, I'm not, for the room is

[10] With this *S*, the adjustments of chair and room were carried out by the *E*, at the *S*'s instruction.

not on its head. It's at an angle. Move me to the right."

At 40° R: "I'm approaching being on my head. Let's experiment some more. Move me to the left."

At 26° R: "If you want to, you can say I'm on my head now. I can't say definitely, but let's say I'm fairly sure I'm on my head. I feel very stupid. Move me to the left."

At 6° L: "I'm not on my head any more. Move me to the right."

At 21° R: "Something else is moving than my chair. [Actually, only the chair was moving.] I don't think I can become straight by moving left and right, for I'm being tilted back. [The chair was capable of left-right movement only.] I'm more on my head than on my seat. Your job is to get me off my head. If I'm on my head, how can this [pointing to the actual ceiling of the experimental room she was in] be the ceiling? Move me to the left."

At 15° R: "Turn me to the left. I'm straighter than before, but I'm not straight. At least, I'm not on my head. Go to the right, without spiraling." When asked whether *E* had been spiraling her, she replied, "I don't know. It's more than left and right. Move me to the right." (It will be noticed that the *S* kept herself throughout very much to the right of the upright, or in the direction of the tilt of the room.)

At 20° R: "I'm going back to my head. Whenever you go to the right, I go on my head. Go to the left."

At 18° R: "I'm going back on my head. Ah, I know. The walls are moving too." When asked whether it was possible to get straight, she replied: "Not by moving left and right. Move the walls back [pointing to the front wall of the experimental room]; we're both oriented down. The front wall is becoming the floor. If you tipped it over a little [pointing forward] it would become the floor. [Suddenly] Now I have a completely different orientation. We're climbing and the front wall is nearer to the ceiling. It's approaching being the ceiling like a plane in ascent." When asked if it were nearer being the ceiling than any other wall of the experimental room, she replied: "Oh, Lord, I've been giving you a bum steer. [Pointing to the front wall of the room] That's the floor. Either the floor or the ceiling. I'm trying to figure it out. If I'm almost on my head, I'm either going down or I'm on the ascent. On that assumption, it's either the floor or the ceiling. [Pointing to the front wall] That's the ceiling—not parallel to the ceiling outside, but it's going up towards it. I'm in a condition of ascent. I used my body too. It's at a crouched angle, so I must be going up. Thank God I figured that out!" When asked where the floor was, she replied: "It's where you are. [This was objectively the rear of the room, which she assumed to be more nearly parallel to the outer floor than at right angles to it.] Move me back to make me straight. As far as right and left go, I'm almost straight, at a very slight angle."

At 17° R: "Does everyone have so much trouble? I'm asking because I just want to feel better for myself."

The trial was discontinued, since it was manifest that the *S* would not be able to regain her bearings sufficiently to make herself straight. When returned to an upright position, she exclaimed: "Oh, it's wonderful! I was hanging like a crescent moon."

An effort was then made to resume the trial, the *S* again being tilted 22° left and the room 35° right. She asked at once that she be moved to the right.

At 12° R: "I'm not straight. Move me more to the right."

At 14° R: "I'm down on my head. If you turn me a little to the left I would be on my head. You would have to move me forward to put me on my head. Move me left."

At 7° R: "It won't help. It's not spiraling that way. Move me right."

At 22° R: "I guess I'm on my head. The right back of the room is nearest the floor, and the left back is nearest the ceiling. The wall with the picture is nearest to the ground. I'm really on my head. I'm displaced from back to front. I'm tilted back about 15° and up on my head." (It will be noted again that the *S* tended very strongly to have her body moved to the right of the upright, or toward the tilt of the room, where it looked straight.)

The trial was discontinued at this point, having consumed fifty minutes without a judgment having been reached.

This performance has many interesting features. First, with rather slight tilts of the chair and room, and these in the right-left dimension only, the *S* experienced extreme changes in her own perceived position and in that of the field. In respect to her own body, she experienced the illusion of tilts in the front-

back dimension, and spiraling movements; and during a good portion of the last trial she felt herself to be on her head, and even to be hanging "like a crescent moon," with her legs forming the upper part of the crescent. In respect to the room, she at one point perceived its front wall as the ceiling, and at another point as the floor, although that wall was objectively perpendicular to floor and ceiling. These shifts in the perceived orientation of the room occurred while the room remained in the same position, and came about quite suddenly. Thus on one occasion, after reporting that the front of the room was becoming the floor, she exclaimed: "Now I have a completely different orientation. We're climbing, and the front wall is nearer to the ceiling." Of extreme importance also is the severe disorientation that the *S* suffered. At many points her perceived upright was very far removed from the true upright in space. In addition, she at times became extremely confused about where the upright was, so that in the last trial she failed to find a position where her body seemed upright, after trying for fifty minutes. Such experiences proved quite upsetting, and the *S* was genuinely disturbed through most of the testing.

The difficulties experienced by this *S* undoubtedly resulted from a strong tendency to perceive the upright primarily on the basis of visual impressions. The readiness with which she accepted the tilted room as straight, even when she sat erect and had the maximal use of bodily cues, provides striking proof of her extreme dependence on the visual field. Further proof of the general importance of visual factors in this *S*'s space orientation is found in her performance in the dark-room situation described in a previous paper(6). In that situation, the *S* was placed in a totally darkened room, and had to adjust a luminous rod, contained in a tilted liminous frame, to the upright. Not only did she displace the rod very markedly in the direction of the tilt of the frame in making it straight, but she also experienced perceptual shifts in the frame itself. That is, she saw first one side of the frame, and then another, as the top, though the frame remained in the same objective position. Her tendency to adjust the rod with the frame, and the perceptual instability of the frame, both reflected strong adherence to the visual framework and insufficient reference to the body.

b. Subject B. A second example of troubled performance on these tests, associated with poor scores, is furnished by *Subject B.*[11] On the three trials of test 1 in which the room was tilted 35° left with the chair upright, she perceived the room as straight at the very outset, and accordingly reported that her erect body was tilted very much to the *right*. On the remaining three trials, when the room was 35° right, it was reported to have undergone a full 90° rotation to the right; that is, its ceiling had become the right wall, and the right wall had become the floor. On two of these trials, the room was reported to be perfectly straight on its side; on the third trial it was seen as almost straight on its side. Significantly, on these three trials the erect body was reported to be tilted to the *right*. In relation to the "new" axes of the room, the body was displaced to the right. If one assumes that this *S* used an essentially visual basis for estimating her position, the judgment of right body tilt makes sense.

The *S* was next given the six trials

[11] Again with this *S*, movement of chair and room was carried out by the *E*, following the *S*'s instructions.

(tests 2 and 3) with body 22° left and room alternately 35° left and 35° right, the task being to make the room straight. Her performance under these conditions merits a verbatim report.

Trial 1—Chair 22° L, room 35° L: [After a long pause] "Well, everything looks normal; but it can't possibly be, because gravity is pulling me to the left like anything. The room looks straight, my chair looks straight, but I'm not. I must be upside down or something. Down must be that way [pointing to the left] because that's the way gravity is. It can't be. I can't figure it out. I guess I'm tilted to the left . . . I must be . . . because I'm falling in that direction. The room looks O.K." (The tilted field was thus accepted as upright.)

Trial 2—Chair 22° L, room 35° R: "Ah, me, the floor is the left wall and the ceiling is the right wall. [When asked if the room was straight] I can't decide. [After a long pause] I'm trying to figure it out. I'm tilted to the *right*, and if I were straight how would it look? It's down to the *left*."

Trial 3—Chair 22° L, room 35° L: "It's crazy. I can't figure it out. ***The room looks all right and I feel all right.*** But still I go this way [letting her left hand hang down]. My chair is slightly *to the right*. I don't know but I go this way [pointing to the left]. . . . The room is straight. [After a long pause] My chair is tilted to the *right*. More than that I cannot say." (Again the tilted field was perceived as upright. Body position was also judged on a visual basis; for in relation to the room, which though tilted was perceived as upright, the body did look tilted to the right.)

Trial 4—Chair 22° L, Room 35° R: "My chair is way to the *right*. The room looks O.K. except that this [pointing to the left wall] is the floor and that [pointing to the right wall] is the ceiling. The room is standing on end. It's standing on one of the walls, but it's straight. It's definitely straight." (Room and body were perceived in the same manner as in trial 2.)

Trial 5—Chair 22° L, room 35° L: "The room is straight. It's again in order. The chair is slightly to the *right*. Then why don't I fall to the right? There is something very mysterious. You must have magnets." (As on trial 3, the tilted room was perceived as upright, and the body, because it was to the right of the room's axes, was perceived as tilted right.)

Trial 6—Chair 22° L, room 35° R: "The room is straight, but standing on one of its walls. My chair is to the *right*."

On the last trial, as on trials 2 and 4, the *S* recognized that the room was not upright. However, it was not simply perceived as tilted, but as about straight in a new orientation—on its side. The body, as a result of this manner of perceiving the room, was judged to be tilted to the *right* each time, though objectively 22° left. The basis of this wrong estimate of body position is the same as that involved in the body-erect series, where a similar phenomenon occurred. With the room seen as on its side, there is a new upright, in relation to which the body is displaced, visually, far to the right. A perception of position based on visual impressions alone therefore leads to the report that the body is tilted to the right. This kind of performance seemed very paradoxical when it occurred in the body-erect series. It was even more striking here, where the body was tilted to the left and a report of right tilt meant even greater violence to the objective situation.

Next described is this *S*'s performance in bringing her body to an upright position (tests 4 and 5).

Trial 1—Chair 22° L, room 35° L: "The room is normal and straight, and my chair is a little bit to the *right*, but I'm being yanked to the left." (Visually, the chair was displaced to the right of the room.)

At 27° L: "I think it's straight now but it can't be because I'm not, but the chair seems to be straight."

Trial 2—Chair 22° L, room 35° R: "You keep doing the same thing. My chair is way to the *right* and the room is on one side, but it looks straight on its end." (As noted in the previous series, with the room seen on its side the body is visually displaced to the right of its upright.)

At 29° L: "Hell, no! For 'looks' it's straight, but not for feeling."

At 20° L: "Now I get it. . . . Now I know the room is standing on one of its cracks." (Though it was recognized that the room was not properly upright, again it was seen not simply as tilted, but as standing on its tip like a diamond. Thus each perceptual shift experienced by the *S* involved perceiving the field in a "symmetrical" way.)

At 12° L: "Now I'm straight. The chair doesn't look straight but feels straight." (Ap-

parently no pressure was experienced at a 12° tilt of the body.) "But the room is cockeyed as hell." (If the room is perceived as standing on its tip, the upright is approximately its diagonal. On the basis of a primarily visual mode of judgment, the body, to be straight, must be displaced toward the left, so that it is aligned with this diagonal. This is what the *S* did.)

Trial 3—Chair 22° L, room 35° L: "I'm cockeyed again. " When asked which way, she replied after a long pause: "I must be tilted to the left, because to get it straight I must go to the right. The room looks perfectly normal, but I know it's not. I can't figure out how, on account of me being so crooked."

At 10° L: "I don't know. It doesn't feel right. Can you move me backwards or forwards?" (When told that that was not possible, she asked to be moved to the right.)

At 7° L: "I think it's perfectly straight now." (Again the body seemed straight when displaced in the direction of the field, though not so markedly as before.)

Trial 4—Chair 22° L, room 35° R: [After a long pause] "If I just go by looks, the room is straight, standing on one wall, and I would be tilted to the *right*. If that were so, but it isn't so. *I have to move to be able to know*. I think I have to go right. . . ."

At 3° L: "No, it's too much."

At 9° L: "I think this is approximately right. That means the room is standing on edge." (As on trial 2, the body was moved toward the room's diagonal, which represents the upright when the room is perceived as standing on its tip.)

Trial 5—Chair 22° L, room 35° L: "The room looks normal. I have to be moved to the right. I'm dangling to the left, but I don't understand. How do you make the chair look straight? It looks a little to the right, but my back is being broken by gravity. . . ."

At 12° L: "I guess I am straight now." (As on trials 1 and 3, the body was moved in the direction of the upright of the field.)

Trial 6—Chair 22° L, room 35° R: "Why do you always do this? It's the same as the time before last. It looks as if it's on one wall, but straight; and my chair is to the *right*. But it feels as if left is down. But it can't be."

At 10° L: "I'm now straight. No, it needs more moving."

At 6° L: "I don't know. I guess I'm straight. The only thing I'm going by is my neck." [When asked about the position of the room, she replied:] "If I'm straight, the room is resting on its edge." (The *S*'s perception of the room, and the method she used in adjusting her body, were thus the same as in trials 2 and 4.)

After this series, the *S* was exposed to a variety of different patterns of movement of chair and room. The room was rocked 10° left and right, while the chair remained stationary. The room was rocked 35° left and right, while the chair remained stationary. The room and chair were rocked 15° in opposite directions. The room was rocked 35° left and right, and the chair 15° left and right. *Through all these the S perceived no room movement whatever.* At all times the changing relation between body and room was assigned to body movement. So sure was the *S* about the absence of room movement that she remarked at one point: "This movement doesn't make me ill at all *as long as you don't move the room.*" At the same time, the illusion of body movement that occurred at times when the body was perfectly stationary was so real that she commented at another point: "My neck doesn't go out when I am at the extreme left, so I must have been crazy before." In other words, her current sensations seemed more valid than those she had experienced previously, when the body was really moving.

In an effort to make the *S* perceive the room movement, *E* asked her to look through the back opening of the room while it was being rocked 35° left and right and the body was stationary. She was extremely surprised to find that the room was moving and she was not. After this opportunity to observe the objective situation, she was asked to face the front of the room again. The illusion of body movement, with the room perceived as fully stationary, returned immediately. Occasionally, by making frequent reference to the outside field, she did find it possible to perceive some room movement for a short while. Thus, knowledge of the true situation was of no help,

and reference to the normal field (outside) only of occasional help, in changing this *S*'s preferred perception of the situation.

Subsequently, further tests were given this *S* in order to gain additional insight into her difficulty and to determine whether anything could be done to improve her orientation. A number of interesting items emerged. First, through learning to place greater reliance on bodily sensations, she did find it possible to infer many times that the tilted room was not upright, despite its continued upright appearance. Her confusion was so great, however, that even after detecting the tilt of the room she could not tell which way it had to be moved to become straight. She stated at such times that if only the room were moved in either direction she could tell at once which was the correct one. This difficulty in determining the direction of tilt of the room was noted in other *S*s, and seemed to occur when the tilt had been established intellectually rather than perceptually. It did not seem to be based on a condition of right-left confusion.

As part of the training procedure, it was suggested to the *S* that in moments of difficulty she close her eyes to eliminate the confusing influence of the field, and establish her position on the basis of pressure sensations alone; and that she then open her eyes while continuing to "hold on to" this felt position, and judge the room in relation to it. She attempted this, but without much success. As soon as she looked at the room, she came strongly under its influence, with the result that the conception of body position, established with eyes closed, was obliterated. In her own words, "I tried closing my eyes and visualizing where the room ought to be, but then when I open my eyes it gets all mixed up." The readiness with which this *S* was influenced by the visual field limited the usefulness of this procedure in another way. For a period after she closed her eyes, the impression of being in the position established under the influence of the visual field persisted. It required some time for the bodily sensation of position to "emerge." At one point, she diagnosed her difficulty very effectively: "It's just that I can't overcome what I see. Even after I closed my eyes I was still affected by what I saw. I had to keep my eyes closed for quite a while to overcome it."

The orientation of this *S* was outstandingly poor. Not only did the limited techniques employed here produce severe disorientation, as reflected in gross misconceptions about the position of her body and of the field, but great difficulty was experienced in making a judgment. She was hesitant and unsure throughout, and each decision required a great deal of time. The judgment finally reached was often made in desperation, and represented the best that could be done under the circumstances. Throughout, the *S* was genuinely disturbed. It is significant, however, that the results were so poor in spite of very real and persistent effort to think through each problem; and this is all the more striking because the problems presented were very simple and the subject outstandingly bright. As with Subject A, the difficulty encountered seems to have resulted from excessive dependence on visual impressions and consequent inability to relate visual and postural experiences. The protocols show how readily she accepted the prevailing field and how much she was affected by appearances in judging her own position.

One of the most striking features of the *S*'s performance was the relation between her perception of body position and her perception of the field. Following is a summary account of how she perceived her body at different stages of the experiment, showing the way in which the perception was in each case dependent on the particular manner in which she perceived the field. (1) When the chair was upright and the room tilted 35° left, she perceived the field as upright and her body as tilted to the *right*. (Since the body appeared to the right of the axes of the room, it was perceived as tilted right.) (2) When the chair was upright and the room tilted 35° right, she perceived the room as standing erect on its right side, and her body as tilted to the *right*. (If the room is perceived as straight on its side, its horizontal becomes the true vertical. In relation to this new vertical, the body appears displaced to the right.) (3) On some trials, when the chair was tilted 22° left and the room 35° right, the room was again seen as standing straight on its side, and once more the body was reported to be tilted *right*. The situations in (2) and (3) were analogous, except that in (3) the body was tilted to the left when reported to be to the right, whereas in (2) it was upright. (4) With chair 22° left and room 35° left, the room was perceived as upright and the body tilted to the *right*. (In relation to the room the body was to the right, and because the room appeared upright this impression was strengthened. It will be noted that in both (3) and (4) the body was tilted to the left, but was perceived as tilted to the right.) (5) On other occasions, when the chair was tilted left and the room was 35° right, the room was seen as standing on its tip, like a diamond, and the body as upright. (In a diamond-like orientation, the diagonal of the room, which is to the left of the upright, represents the true vertical; and under these conditions the body was moved toward alignment with the diagonal, or to the left, in order to make it straight.)

If the *S*'s judgments of body position were considered without regard for the field, her behavior would appear very variable and random. Only when the field is taken into account does it become clear that body position was at all times judged in relation to some visual frame of reference, and that the behavior was highly systematic. Moreover, in considering the effect of the field it is necessary to view it not in terms of its objective structure but as it was perceived by this *S*. The problem of detecting the systematic basis of her behavior is made particularly complex by the instability of her perception of the field. Thus, the room at a 35° tilt was sometimes perceived as upright, sometimes as standing straight on its side, and sometimes in a diamond-like position; and each change in the perceived position of the room was accompanied by a change in the perceived position of the body.

c. Subject C. It has been seen that Subjects A and B, though very bright, were not at all successful in overcoming their strong visual impressions through intellectual analysis of the situation. This is demonstrated even more strikingly in the performance of another bright *S*, *Subject C*, who also had the technical knowledge about sensory mechanisms necessary to deal with his conflicting experiences. Despite an intensive effort to solve the problem, and the knowledge with which to do so, he proved unsucess-

ful and gave a strongly visual and confused performance. Some of his protocols may be cited to show how fruitless were his efforts at computation in the face of strong and more immediate perceptual experiences.

In one test, while the *S*'s eyes were closed, the chair and room were tilted 22° to the left. Upon opening his eyes, he commented: "Now I think I'm upright, even though I feel the devil over to the left. But on the basis of visual and spatial cues I decide the sensory impression of left tilt is false. The cue of pressure must be from being tilted the other way before; it's like the Barany chair phenomenon." On another trial the *S* was tilted 22° left and the room 35° left. His comments were: "The whole room is 90° on its side. The left-hand wall is the floor. I am directly on my left side. Actually, on the basis of other conceptions, I am willing to predict I am upright. When I let my hand swing, it goes right down, not to the side. The actual case is, I think, that I and the room are upright; but I still have the impression that the room is on its side. Hmm, I'm marvelling at the inadequacy of my static receptors; I'm dammed if I'd bet a nickel on where I'm sitting and how! My final word is, the room is upright, and me too [objectively, not only were the room and chair considerably to the left, but there was a 13° angle between them] but both feel on the side." On still another trial of this series, the chair was initially 22° left and the room 35° right. His comment was: "I'm on the left side and the room is a little to the right." When the chair had been moved toward the right to a point were it was 14° right, he said: "Wow! I'm upside down. I feel suspended from the floor position. I have a hunch, though, that objectively I'm still a little to the left; yet when I look it seems the right wall is the bottom, even though I know it is not so. I'm jutting out like a branch from the floor part, that is now the left wall; but I know it's not true—I could find out by spitting." One sees here how difficult it is for a person who is strongly influenced by visual impressions to make use of his intelligence and his knowledge about sensory mechanisms in order to counteract these impressions and to achieve a satisfactory integration of visual and postural experiences.

2. *Subjects with Poor Scores Who Gave Untroubled Performances*

Performances such as the three just described occurred almost exclusively among *S*'s who made very large errors in judging the upright. Nevertheless, these cases represent extreme examples of this category, particularly in terms of the amount of difficulty and confusion experienced. When confusion occurred among poor *S*s, it was usually milder and more transient, and was restricted mainly to a part of the test. And as a general rule, *S*s with large errors made their judgments in rapid, untroubled fashion, without evidence of conflict. The general picture in these cases was one of a glib, unquestioning acceptance of the visual field.

An example of this type of performance is provided by *Subject D*. In test 1, where the chair was upright and the room tilted 35° left or right, she accepted the room as straight at its initial 35° tilt on all six trials. In tests 2 and 3, were the chair was tilted 22° left and the room 35° left or right, the room was again perceived to be upright at the initial 35° tilt on all trials. Despite the

very large errors involved, her judgments were made quickly and confidently, without conflict. In the chair-adjustment series (tests 4 and 5), the *S* did have some difficulty, and complained that she could not get herself straight. She quickly gave up trying, however, and simply stated that she had done her best. Regardless of the initial relation between room and chair, she moved her body in the direction of the tilt of the room on every trial of the series. On one trial her body was tilted as much as 24° when she said it was straight. Later this *S* was submitted to various patterns of rhythmic movement of the room alone and the room and chair together. Throughout she failed to perceive any movement of the room whatever, ascribing all the changes to movement of her body; and this judgment was always confidently made. The absence of confusion as well as the ease in making judgments clearly represent an important difference between the performance of Subject D and those of Subjects A, B, and C, though both types of performance involved marked dependence on the visual field.

D. The Effect of Visual Impressions of Position on Pressure Sensations

One of the interesting observations made in the experiments described above was that visual impressions not only act as an important determinant of perceived body position for many *Ss*, but actually seem to obscure postural experiences, so that they are not noticed. Those experiments did not definitely provide a measure of "unexperienced" pressure sensations, however, since the instructions only required the *S* to "make himself straight." Therefore it was decided to investigate this problem further by giving chair adjustment tests with new instructions, which called specifically for a position where no pressure was felt on either side of the body.

In the first experimental condition, room and chair were tilted 30° to the same side, and the room remained tilted while the chair was straightened. In the second condition, room and chair were again tilted 30°, but to opposite sides. Four trials were given under each condition. The *S* was instructed to bring his body to a position where he felt no pressure on either side of the body. Also, on every trial, after he had reported that he was erect the *S* was asked: "Do you now feel no pressure whatever on either side of your body?" If he said that he did feel pressure, he was moved farther. Thus every effort was made to insure an adjustment based on bodily sensations. The movement was carried out by the *E* rather than by the *S* himself as in the previous experiment. The *E* moved the chair 2° at a time, and after each turn the *S* indicated whether or not he felt straight by saying "More" or "Enough."[12] Fifteen *Ss* were used in this experiment, 3 males and 12 females, all Brooklyn College students.

Control data were provided by a group of 31 *Ss*, (4 males and 27 females, all Brooklyn College students) who were also tested by this stepwise procedure but who received the original instructions, which simply called for an upright position without emphasizing the elimination of pressures. As with the experimental group, these control *Ss* received four trials for each of the two conditions used. A second type of con-

[12] This procedure was used in later experiments. It was found that when permitted to make adjustments themselves some *Ss* "experimented," moving the chair back and forth. This not only increased the testing time, but also made for more varied conditions betwen *Ss*.

trol data was obtained from an extra test given to the fifteen *Ss* of the experimental group. In this test the body was tilted 30° left and again had to be brought to a point where there was no pressure on either side; but the task was performed this time with eyes closed. Straightening of the body was carried out by the *E*, using the stepwise procedure. Each *S* received four trials under these conditions.

The results show that, despite the emphasis on postural experiences in the instructions, the body was often quite tilted when perceived as upright. For the group as a whole, the mean deviation of the body adjustments from the true upright was 13.3° when the room was initially tilted with the chair, and 7.8° when room and chair were tilted in opposite directions. That the errors were due mainly to the influence of the tilted field is indicated by what happened when *Ss* were asked to close their eyes after reporting an absence of pressure. As a rule they reported an immediate and often strong sensation of pressure against the side to which the body was objectively tilted. Further evidence of the influence of the field is the finding that the errors in adjusting the body were most often in the direction of tilt of the room. With the chair initially tilted 30° left, and the room also 30° left, the chair remained tilted to the *left* in 96.6% of all adjustments. With the chair initially tilted 30° left, and the room 30° right, the chair was tilted to the *right* in 61.6% of all adjustments.[13] In the latter experimental condition, as the body moved from 30° left over to the right side, it passed through a position where it was truly upright; and yet this position was not perceived as the correct one. In some individual cases, the body was tilted very far in the direction of the field, so that the pressure that went unnoticed was considerable. For example, in the chair-30°-left, room-30°-left condition, two *Ss* in one of their trials reported that they felt no pressure and that the body was upright at the very outset, *when it was tilted 30°* to the left. At the time, the body was in alignment with the field, so that—judged by appearances alone—it seemed perfectly upright. On 11 of the 60 trials given under this condition, the chair was tilted 20° or more when the *S* reported an absence of pressure, and in every instance it was tilted to the left, or toward the room. In the chair-30°-left, room-30°-right condition, the body was tilted to the right as much as 24° on two of the 60 trials given. On 11 trials, the body was tilted 15° or more when reported straight, and on 8 of these it was tilted to the right or toward the room. It is clear that the adjustment of the body to these often markedly tilted positions resulted from the influence of the tilted field. It is equally clear, in view of the instructions used, that pressures against the side, which existed in these positions, were not experienced.

While there was a generalized tendency for pressure sensations to go unnoticed under the influence of visual impressions, there were at the same time marked individual differences in this regard. The mean tilt of the body when reported to be upright ranged from 6.0° to 22.5° for the chair-left-room-left condition, and from 2.3° to 17.3° for the chair-left-room-right condition. It is thus indicated that people differ widely in the extent to which visual impressions of

[13] It was brought to the true upright in 8.3% of the adjustments, and displaced opposite to the field in the remaining 30.0% of the adjustments.

position submerge pressure experiences.

For some *Ss*, the new instructions did not eliminate the dilema of feeling straight when appearing tilted or appearing straight when feeling tilted. The instructions helped simply by directing them to the postural rather than the visual basis for judgment when confronted by such a conflict. Thus some *Ss* reported in a given position that they felt no pressure to either side and that the requirements of the task had therefore been met, but added that they knew the body was really not straight. The latter belief was based, of course, on the continued tilted appearance of the body. In other instances, when the *S* reported that he no longer felt any pressure he added that the room, which was displaced in the opposite direction from him by a very considerable amount, was upright. *Ss* who behaved in this way did not believe that the position to which the body had been adjusted represented the true upright. For them, the visually indicated upright had greater validity, and the task set for them by the new instructions, which emphasized body experiences, led to a more "unnatural" result than the old freer ones.

A comparison of the results for the experimental group with those for the control group that received the original freer instructions indicates that the emphasis upon pressure experiences had some effect on the extent of influence of the visual field, but that this effect was surprisingly small. For the room-tilted-with-body condition, the mean errors in making the body upright were, in the control and experimental groups respectively, 13.3° and 15.9°. For the room-tilted-opposite-body condition, the corresponding values were 7.8° and 10.4°.[14] For both types of room-chair relations and with both kinds of instructions, the body was usually tilted in the direction of the room. While in each case the body was not tilted so far with the body-orienting instructions, the amount of tilt was not very much less than with the free instructions; for each room-chair relation, the difference was only 2.6°. To the extent that the body-orienting instructions reduced the influence of visual factors, they did so not only by producing a greater consciousness of body experiences but also by forcing a decision in favor of postural impressions when the conflict between them and visual impressions could not be reconciled.

For the second control experiment, where the body was straightened with eyes closed from an initial tilt of 30° left, the mean error in making the body upright is found to be 7.1°.[15] In 86.6% of the adjustments, the body remained displaced to the side of its initial tilt, reflecting the negative after-effect discussed earlier. Comparison of these results with those obtained when a visual field was present provides further evidence of the effect of visual factors on pressure experiences. First, in the chair-

[14] It will be noted that the errors of the control group are larger than those reported previously for tests 4 and 5 when the same free instructions were given. The difference undoubtedly depends on the kind of movement used in straightening the chair in each case—that is, the stepwise movement here and the continuous movement in the previous experiment. With the more gradual stepwise procedure, the *S* is more likely to stop at the very first point at which he feels comfortable. With the more rapid continuous movement, on the other hand, there is a greater possibility of "shooting" beyond this point, especially when the *S* carries out the movement himself.

[15] The deviation here is larger than that obtained in the corresponding eyes-closed test (test 6) of the previous experiment. Again, the difference may be attributed to the use of stepwise movement of the body here and continuous movement there.

30°-left, room-30°-left condition, the mean error was 13.3°, and in 96.6% of the adjustments the body was tilted to the left of the upright. Thus the body was tilted an average of 6.3° farther to the left when there was a visual field tilted 30° left than when no field was present. Since in both cases the body was brought to a position where no pressure was experienced, this difference indicates that the location of the field helps determine the point at which the body *feels* straight. In the chair-30°-left, room-30°-right condition, the mean error was 7.8° —a value only slightly different from the 7.1° obtained with eyes closed. Although the mean tilt of the body was about the some in the two cases, the predominant direction of tilt was quite different. With eyes closed, the body was tilted to the left in 86.6% of the adjustments, and to the right in only 3.3% of the adjustments.[16] With the field 30° right, on the other hand, the body was tilted to the left in only 30.0% of the adjustments, and to the right or toward the field—in 61.6% of the adjustments. Thus the introduction of a field tilted to the right caused a marked shift in the direction of the errors in adjusting the body, from the left to the right side.[17] Since again both experimental conditions called for adjustments to a no-pressure position, it is seen once more that visual impressions may affect postural experiences.

[16] In the remaining 10.0% of the cases, it was brought to the true upright.

[17] Errors in the direction of the field were smaller and less frequent in the chair-left-room-right condition than in the chair-left-room-left condition, because of the influence of the negative after-effect. Since the body was initially displaced to the left, the negative after-effect worked in the direction of leaving the body tilted to the left. This reinforced the influence of the field in the chair-left-room-left condition, but diminished it in the chair-left-room-right condition.

These experiments demonstrate, then, that visual impressions of position may be strong enough to suppress contradictory pressure sensations. There is found a marked tendency to tilt the body in the direction of the tilt of the field, and, moreover, to *feel* straight in the tilted position. With some individuals, the pressure produced by being tilted was estimated without great error, despite contradictory visual impressions, and such people were quite accurate in straightening the body. In other *S*s, pressure experiences were so greatly affected that, as found in two extreme cases, body tilts as large as 30° went undetected. Not only is it possible for visual impressions to submerge contradictory pressure experiences, but they may also induce supporting pressure experiences. Thus some *S*s, sitting *erect* in the tilted room, reported that their bodies were tilted, and that they felt pressure on the side of the "tilt."[18]

E. The Effect of Varying Magnitudes of Body Tilt and Field Tilt on Perception of the Upright

It has been found, throughout the experiments on perception of position, that tilting the field causes the perceived upright to be displaced from the true upright in the direction of field tilt. It has also been observed that tilting the body leads to a readier acceptance of the visual field than occurs when the body it upright. In the experiment to be described here, the room-chair apparatus was used to make a systematic study of the effect on the perceived upright of different magnitudes of tilt of body and field. Three tilts of the chair were em-

[18] In part, these sensations may have been real, resulting from the *S*'s pressing his body against the side of the chair under the influence of the visually induced illusion of tilt.

ployed: 5° right, 15° right, and 22° left. With each of these, five different tilts of the room were used: 35° and 20° to the same side as the chair, and 10°, 20°, and 35° to the opposite side from the chair. These 15 room-chair combinations were presented in a random order to each of 35 *S*s. These were all male enlisted personnel attached to an Air Forces psychological research unit.

pointer clockwise or counterclockwise. An extension protruding at right angles from the shaft moved against a protractor, making it possible to determine the position of the pointer. The pointer was initially aligned with the tilted room, and if it was not perceived as upright at the outset *E* moved it in small steps, at the *S*'s direction, until it was reported upright.

TABLE 2

DETECTION OF TILT OF FIELD WITH VARYING MAGNITUDES OF BODY TILT AND ROOM TILT

The *number of times* the room was perceived as upright at the very outset is given for each of the 15 room-chair combinations employed. Since each of the 35 *S*s made a single judgment under a given condition, the maximum value possible for any condition is 35.

Body Position	Room Position								
	Room Tilted with Body				Room Tilted Opposite Body				
	35°	20°	Total	% Aver.	10°	20°	35°	Total	% Aver.
5°	3	2	5	7.1%	12	3	2	17	16.2%
15°	0	0	0	0.0%	18	8	6	32	30.5%
22°	1	4	5	7.1%	27	23	10	60	57.2%
Total	4	6	10		57	34	18	109	
% Average	3.8%	5.7%	4.8%		54.3%	32.4%	17.1%	34.6%	

Two types of data were obtained on each trial of this experiment. First, on opening his eyes the *S* described both his own position and the position of the room. These reports established the frequency with which the field was perceived as upright in its initially tilted position, under different conditions. Second, the *S* adjusted a pointer, mounted on the front wall of the room and initially aligned with the room's vertical axis, to the upright. This pointer-adjustment procedure was a means of determining the effect of a given tilt of the field upon the perceived external upright.

The base of the pointer was attached to a shaft running to the outside. By turning this shaft, *E*, standing out of view of the *S*, was able to rotate the

1. *Results on Perception of Room Tilt*

Table 2 gives the data of the first type obtained in this experiment—indicating the frequency with which the room was perceived as upright with each room-chair combination employed. Results for the room-tilted-opposite-body and the room-tilted-with-body conditions are presented separately, on the basis of the earlier finding that the two types of conditions yield quite different results. In all the *room-with-body* combinations together, the room was perceived as upright in only a negligible number of trials (10 out of 210, or 4.8%). With such small values it is not surprising that no relation is apparent between the frequency with which the room was perceived as upright and the amount of

room or body tilt. The results for the *room-opposite-body* conditions present quite a different picture. On a considerable number of trials (109 out of 315, or 34.6%) the tilted room was perceived as fully upright. Further, as the tilt of the *body* increased, the room was more often perceived as upright. Also, as the tilt of the *room* increased, it was less often perceived as upright. The latter result means simply that the farther the field was displaced from the upright the more readily its displacement was detected.

TABLE 3

AMOUNT OF SHIFT OF PERCEIVED UPRIGHT WITH VARYING MAGNITUDES OF BODY TILT AND ROOM TILT

The *mean amount of error* in adjusting the pointer to the true upright is given for each room-chair combination. The errors were almost invariably in the direction of the tilt of the field. N, in each case, is 35. The average values for different body tilts for the room-with-body and room-opposite-body conditions are not directly comparable, since two room positions were used for the former condition and three for the latter. Because the extra room position used involved a small tilt of the room (10°), the means for the room-opposite-body condition are somewhat lower.

Body Position	Room Position						
	Room With Body			Room Opposite Body			
	35°	20°	Mean Error	10°	20°	35°	Mean Error
5°	20.9°	12.2°	16.6°	6.8°	10.0°	18.6°	11.8°
15°	18.1°	13.0°	15.6°	8.7°	14.2°	25.1°	16.0°
22°	16.0°	12.7°	14.3°	9.6°	18.5°	28.0°	18.7°
Mean Error	18.3°	12.6°		8.4°	14.2°	23.9°	

2. *Results on Pointer Adjustment*

The data of the second type obtained in this experiment, those on pointer adjustment, are presented in Table 3. Again the room-opposite-body and the room-with-body conditions are treated separately. Results for the *room-opposite-body* condition show that with increasing *body* tilts the pointer was displaced farther in the direction of the field. These data, then, match the body-position-judgment data in showing greater acceptance of the field at larger body tilts. In fact, with the body tilt of 22° dependence on the field was so great that the average position of the pointer after adjustment was close to the vertical axis of the tilted room for each of the three room positions employed: 9.6° for the 10° tilt of the room (within 0.4° of the room's axis); 18.5° for the 20° tilt (within 1.5° of the axis); and 28.0° for the 35° tilt (within 7.0° of the axis). Regarding the effect of magnitude of *room* tilt, the table shows that increased tilts of the room led to larger tilts of the pointer. As the field is tilted, it "takes along" the perceived upright.

It remains now to consider the pointer-adjustment results for the *room-with-body* type of condition, also shown in Table 3. Here, increasing the tilt of the *body* has no clear-cut effect on adjustment of the pointer. At the 35° room position, there is a tendency toward smaller errors in judging the upright with increased body tilts. For the 20° room position, the results for all three body tilts are about the same. The effect of increased tilts of the *room* is clear-

cut, however, and is the same as for the room-opposite-body condition. As the room is tilted farther, the tilt of the pointer also increases. The extent of influence of the field upon perception of the pointer is indicated very strikingly in the results obtained when the chair was tilted 5° right and the room 35° right. In this condition the pointer was tilted an average of 20.9°, or an average of 15.9° farther than the tilted body. It was, of course, consistently tilted toward the field, or to the right. This result of tilting the pointer farther than the body was obtained with most *Ss*. When an *S* made an adjustment of this kind, he might have recognized, if he had reasoned about it at all, that a pointer which was tilted even farther than his own tilted body could not possibly be upright. However, it is evident that the pointer looked so "proper" in the context of the room as to block any such attempt at intellectual analysis. It is also true that in some cases the perceived position of the body itself was affected by the tilted field. Though tilted to the right, eight *Ss* reported that they were tilted to the left. If the experience was one of being tilted to the left, it was possible for the pointer to be to the right of the body and still appear upright.

These pointer-adjustment results for the body-with-room condition should be related to the results reported earlier on initial judgments of the room. It will be recalled (Table 2) that in this condition the room was rarely perceived as upright. It is now found that, although the tilt of the room was recognized throughout, the *Ss* still tended to "go along with it" in adjusting the pointer; and that the more the room was tilted the farther the pointer was tilted. The pointer-adjustment data undoubtedly are a better index of the effect of increasing field tilts than are the initial judgments about the room. The latter provide an all-or-none measure, since *Ss* simply reported that the room was straight or tilted; differentiation among *Ss* in terms of *amount* of apparent tilt was not possible. The pointer-adjustment procedure did allow such a differentiation, since the *S* might adjust the pointer in accordance with how tilted the room appeared to him.

Results previously reported have shown that tilting of the visual field causes a shift of the perceived upright in the direction of the field. The findings of the experiment reported now permit an extension of this generalization. They show that the amount of shift of the perceived upright is in proportion to the amount of displacement of the field. As for the effect of tilting the body on perception of the upright, it was found in previous experiments that when the body is tilted there is a readier acceptance of the prevailing field than when the body is upright. It was also found that tilting the body opposite to the field makes for even greater acceptance than tilting it with the field. This experiment has taken the problem a step further. It has demonstrated that, at least when the body is tilted opposite the field, the more the body is tilted the greater is the tendency to accept the visual field. Apparently, with increasing tilts the body becomes less useful in making judgments, and perception of the upright is therefore based more and more on the surrounding field. The magnitude of tilt of both body and field thus determines in a specific way the degree of shift of the perceived upright.

F. Consistency of Performance

To investigate consistency of performance under different room-chair conditions, the results for the following tests described in section B were intercorrelated: (1) room adjustment with chair upright, room tilted 35° left or right (test 1); (2) room adjustment with chair tilted 22° left, room tilted 35° left or right (tests 2 and 3); (3) chair adjustment, with chair tilted 22° left, room tilted 35° left or right (tests 4 and 5). The following r values were obtained: (1) *vs.* (2), +0.82; (1) *vs.* (3), +0.45; (2) *vs.* (3), +0.44. The correlation between scores for the two room-adjustment tests (1 *vs.* 2) is higher than the correlation between either room-adjustment test and the chair-adjustment test (1 *vs.* 3 and 2 *vs.* 3). Generally, the r's obtained are sufficiently high to indicate a relationship among the conditions employed. To the extent that in each test a high score represents great influence by the visual field, it is indicated that a given degree of dependence on the field is a general feature of a person's orientation, whether the orientation relates primarily to his own body or to the field "out there."

The results of another experiment are relevant to this problem of consistency. The 35 *Ss* used in the pointer-adjustment experiment described in the previous section were later given another test in which the task was to make the room straight. Eight trials were given in all. On half of these the *S* was tilted 22° left, and on the other half 22° right. Further, on half of all trials, the room was initially tilted 35° to the same side as the chair, on the other half 35° to the opposite side. In adjusting the room, the step-wise procedure was used, with movement carried out by the *E*. The correlation between scores on this room-adjustment test and scores on the pointer-adjustment test was +0.639. A tendency to displace the pointer toward the tilted field in the pointer-adjustment test is thus associated with a tendency to accept the prevailing tilted field as upright. Although the two tasks are similar, there is an important difference between them. In the room-adjustment situation, the whole field is moved, so that the visual frame of reference itself is altered in the adjustment. In the pointer-adjustment situation, on the other hand, the visual frame of reference remains in its initial position, so that judgments are made under its continuing influence. The finding of a correlation between these two types of situation suggests that people who readily perceive the prevailing field as upright also tend to come strongly under the influence of the field in the perception of items contained within it.

Further evidence of consistency in performance was found when *Ss* used in the room-adjustment and chair-adjustment tests (1 to 6) were also tested in the dark-room situation of an earlier study (6). In that situation the task was to adjust a luminous rod contained in a tilted luminous square to the true upright. When the eariler scores for rod adjustment with body tilted are correlated with the later scores for room adjustment with body tilted, r is found to have a value of +0.437. This reflects a tendency on the part of people who accept the tilted field in one of these situations to accept it in the other also.

The correlations obtained among the rather varied orientation conditions considered indicate some consistency in the extent of a person's dependence on the visual field in his perception of both the external upright and the position of his own body.

G. Illness Brought about by an Unstable Visual Field

In the course of testing in the tilting-room-tilting-chair apparatus employed in these experiments, some *S*s complained of feeling ill. The symptoms included dizziness, headache, sweating, and nausea. Since there was some indication that the illness might be associated with movement, a systematic series of tests involving different patterns of room and chair movement was carried out: (1) The *S*, with eyes closed, was tilted 10° left and right. (2) The *S*, with eyes open, was tilted 10° left and right, while the room remained stationary. (3) The *S* remained in an upright position while the room was tilted 10° left and right. (4) The *S* remained in an upright position while the room was tilted 35° left and right. (5) The *S* and the room were moved together, 15° left and right. (6) The *S* and the room were moved in opposite directions, 15° left and right. In all six patterns, the chair or room, or both, were moved back and forth ten times. This series was given to 45 *S*s, 12 males and 33 females, all but a few of whom were Brooklyn College students.

Although this experiment was preliminary in nature, it yielded several clear-cut results. First, in not a single instance did body movement alone, whether with eyes closed or with eyes open (conditions 1 and 2) produce any ill effects whatever. Body movement together with room movement (conditions 5 and 6) did produce some discomfort, but only occasionally, and then usually in a mild form. The most severe discomfort occurred with room movement alone (conditions 3 and 4), the 35° movement (condition 4) being more effective in this regard than the 10° movement (condition 3). In the 35°-room-movement situation, several *S*s became so ill as to request that the movement be stopped within a few seconds after it had started.

The observation that movement of the visual field may produce illness is of course not at all new. There is still the problem, however, of how visual movement alone—in the absence of body movement and, therefore, of direct labyrinthine stimulation—can produce illness. There is already some evidence that movement of the field, by creating an unstable situation, helps induce disorientation, and that this, rather than the movement per se, is responsible for the illness. Several additional observations made in our experiments may be cited to support this view.

As was noted earlier, when the visual field is set in motion there develops an illusion of body-movement, which, of course, is not supported by corresponding changes in bodily pressures. This often results in uncertainty about whether or not the body is really moving; and this confusion about what is happening may prove disturbing. It was found in the test described above, where the body was stationary and room rocked back and forth, that the most severe discomfort occurred during reversal of room movement. This was also the point at which *S*s found it most difficult to establish what was happening. When the room reaches its point of maximum excursion and reverses direction, the illusory body movement is also reversed. The occurrence of a *change* in perceived body movement draws attention to the body. This renews the conflict between visual and postural cues, which is often "stilled" during the previous continued movement of the room when

the *S* may more glibly "go along with" visual impressions.[19] Moreover, the disparity between visual and postural experiences is greater at reversals than during continuous movement. If the body were really moving, as indicated by visual impressions, there would be a shift in pressure from one side of the body to the other during reversal, but only a very gradual increase of pressure on one side during continuous movement. Since the body remains upright and stationary, there is no actual pressure—of either kind—to support the illusion of movement; but this absence of pressure is more apparent at reversal, when a *shift* in pressure is to be expected, and the disparity between appearances and postural sensations is therefore more prominent. Clearly there is heightened sensory conflict at reversal. The fact that the discomfort is also greatest at such times provides evidence of a connection between illness and disorientation. In this connection, it is also indicated that *Ss* whose orientation was generally poor had a greater tendency to be made ill by visual movement. The difficulty in orientation which they ordinarily experienced, because of being excessively influenced by visual impressions, was apparently enhanced when the field was made unstable.[20]

Further evidence of a connection between disorientation and illness comes from the finding that the introduction of real body movement served to eliminate or minimize the illness. Room movement alone was the most effective means of producing illness. With a combination of room movement and body movement, illness occurred only rarely, and then in a mild form. Finally, body movement alone never produced illness. The incidence of illness in these three situations is in direct proportion to the difficulty encountered in maintaining orientation. With room movement only, as noted, there is often uncertainty about whether the room alone, the body alone, or both together are moving. The second situation, where both room and body are moved, proves less confusing, because here the visual impressions of movement are accompanied by real pressure sensations. Although the pressure does not correspond fully to the visually perceived movement, the contradiction is not so great as when the body is stationary. Finally, with body alone moving, no one is in doubt at any time about what is happening. Every *S* is able to establish throughout that the body is moving and the room is stationary. Under these circumstances, where there is no sensory conflict and complete certainty of orientation, no one becomes ill. It is thus indicated that with increasing difficulty in integrating sensory experiences illness is more likely to occur.

Illness sometimes occurred during the basic room-adjustment and chair-adjustment tests described in section B (tests 1 to 5); and observations about the time

[19] That the change at reversal does lead to renewed attention to the body is supported by the finding that many *Ss* who during continuous movement of the room reported body-movement only, reported room movement also during reversals. The perception of room movement reflects a recognition that the body cannot be doing all of the moving. This indicates a better estimate of body pressures, brought about by greater attention to the body.

[20] Paradoxically, some of the *Ss* who were very strongly influenced by visual impressions were not disturbed by visual movement precisely because they accepted the field to a very great extent. To such *Ss*, the moving field appeared stationary throughout, and only the body seemed to be moving. So strong was this impression that the *S* felt entirely certain of his orientation.

and nature of its occurrence there serve to confirm the belief that illness is based on disorientation. In these cases, illness was reported when an *S* opened his eyes at the beginning of a trial and found the room and his body tilted. The typical complaint was that everything seemed topsy-turvy and that this made him feel dizzy. Thus the illness—sometimes of a very severe character—occurred in the absence of any visual movement at all. The speed with which the illness developed, and the circumstances under which it occurred, strongly suggest that it was a consequence of being confronted suddenly with an unstable situation, resulting in a marked, if temporary, loss of orientation. This may be seen in the performance of the following *S*.[21]

Illness developed during tests 4 and 5, in which she was required to straighten her body in the presence of a tilted field. It will be remembered that on trials 1, 3, and 5 of the series the chair was initially tilted 22° left and the room 35° left, and on trials 2, 4, and 6 the chair was 22° left and the room 35° right. The *S* was very strongly affected by visual impressions, and so tended to move her body toward alignment with the field to straighten it. On the first trial she encountered no difficulty and felt entirely all right. Illness developed on the second trial. She reported at the outset that the room was straight and her body tilted left. She moved her body to 23° right—far in the direction of the room—but then seemed to recognize that it was tilted too much and returned it to 20° right. At this point she complained of feeling very ill. That she had lost her bearings at the time is suggested by the comment made just prior to this point: "I don't know which way I am, but I'm not straight." She removed her head from the headrest, saying that she was nauseated. Testing was resumed after a while, and now the *S* moved herself to 13° right. She complained of continuing nausea. Then she reported that she was feeling very ill, and asked to be let out of the apparatus. She complained, in particular, that she felt like vomiting. After about five minutes she felt better and agreed to return to the apparatus to resume testing. On the next three trials (3, 4, and 5) she encountered no difficulty in making judgments, and reported no illness. On the sixth trial, however, the illness returned. On this trial, the same condtions were employed as on trial 2, the one during which she had previously become ill—room tilted 35° right and chair 22° left. She moved her body to 12° right, or toward the tilted room, and then reported: "I've lost my sense of balance. I do in this position every time. This is the position in which I became nauseated before." She asked to be let out of the apparatus, complaining of nausea, headache, and dizziness. On coming out she closed her eyes. She then said she felt like vomiting, and asked to be taken to a sink. She seemed to make retching movements, but did not vomit.[22]

This marked illness developed while the room was stationary, though tilted, so that no visual movement was involved. At the moment the illness became severe, the *S*'s body also was stationary; and preceding that it had been moved briefly in 2° steps, with a period for observation after each movement. Movement of the body was thus mini-

[21] The *S* stated that she felt perfectly well when she reported for the experiment.

[22] Later this *S* was exposed to movement of the field, the room rocking 35° left and right about her stationary body. Forty seconds after the movement began, she complained of feeling nauseated and asked to be let out of the apparatus.

mal, and hardly enough to account for such drastic illness. It is also significant that similar amounts of body movement at other ploints in the test had no effect at all. The discomfort that occurred under these rather static conditions seems to have been related to the difficulty she encountered in getting her bearings. She became ill on two of the six chair-adjustment trials, and on each she complained of "not knowing which way I am," or of having "lost my balance." The same condition was employed in both these trials, and she specifically complained of finding that condition difficult. Although she did not become ill on the fourth trial, which also involved the same condition, neither did she report any specific difficulty in getting her bearings on that trial. On the other three trials of this chair-adjustment series, involving a different condition, she encountered no difficulty and no illness occurred. Similarly in the room-adjustment tests (tests 1, 2, and 3) that preceded the chair-adjustment series, she had experienced no difficulty in reaching a decision, and had felt no illness. Although she had accepted the room in a very tilted position in these tests, she had made her judgments quickly, and usually stated that she thought she was doing rather well. Thus throughout this *S*'s performance a relation was apparent between illness and difficulty in determining position.

The *quality* of the illness involved in these experiments also suggests that it was due to some disturbing experience, as disorientation, rather than to any direct physical stimulation. To illustrate this quality, we may cite a more generally familiar experience, such as that of sitting in a train that is being passed by another train, so that there is uncertainty about which is really moving. The sensation of dizziness felt at such times is accentuated when, by changing reference points, a sudden shift is brought about in what is perceived to be moving.[23] The discomfort involved seems to have a component of *anxiety*, which is part of the reaction to an unstable situation. This same quality may be recognized in the reactions of *S*s who became ill in our room-movement experiments, where the disorientation was more enduring and the illness more marked. In fact, two *S*s, who became ill to the extent of asking that movement be stopped immediately after it has begun, described the distress they felt as "anxiety attacks." The violence with which they reacted and the content of their experience left no doubt that we were dealing here with a very anxious reaction to a threatening situation. It is significant in this connection that there seem to be important differences between this type of illness and the motion sickness produced sometimes in body-movement situations. The latter illness has more of a "physiological" character, including such symptoms as projectile vomiting, which may come on in the absence of any previous distress. The disturbance found in these experiments seems to be more "subjective," with symptoms like projectile vomiting entirely absent.

These various items of evidence indicate that visual movement produces illness through providing an unstable situation, in which it is difficult to remain oriented.

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[23] The disturbance experienced under these conditions cannot be ascribed to visual movement as such, because it does not occur when viewing the passing scenery through the window of a moving train, or when standing on a platform and watching a train go by. The important factor is not the movement, but the uncertainty about one's position that the movement produces.

IV. DISCUSSION

Because the visual field employed was a more impressive one, and because more extreme positions of the field were used, the present experiments produced more striking evidence of the importance of the field in perception of the external upright than appeared in previous studies. It was found, in particular, that the field was perceived as "proper," and its upright accepted as the true upright, under a great variety of conditions. Some *Ss*, for example, perceived the field as properly upright, and therefore as remaining in the same position, over a range of 70°. In experiments employing a 56° tilt of the room, to be reported in a later paper, the field appeared unchanged for some people over a range of 112°. The persistent acceptance of the field by some *Ss* was most strikingly illustrated by their inability to perceive any movement in the room when it was tilted from side to side in a rhythmic fashion while the body remained stationary. Such *Ss* assigned all of the changing relation between body and field to movement of the body, even when the room was moved through an arc of 70°.

Evidence of the kind just summarized demonstrates how important a role the visual field may play in perception of the external upright. At the same time, these experiments once again revealed striking differences among people in the extent to which they derive the perceived vertical and horizontal from the surrounding field. Whereas some *Ss* tended to perceive each new field as straight, and the upright of the field as the true upright, others, at the opposite extreme, were able to establish the upright quite independently of the field. These differences among *Ss* are not simply based on differences in the interpretation of perceptual data, but reflect differences in the quality of perception itself. It was found that under the very same conditions the field appeared very tilted to one *S*, mildly tilted to another, and perfectly upright to still another.

Although this study provided further information about perception of the external upright, its most significant results relate to the influence of the field on perception of body position both while stationary and while moving. The basic fact that the perception of body position is greatly influenced by the relation of the body to the field is actually well established.[24] The present study, however, has advanced the problem in two ways. First, it provided more extreme evidence than was hitherto available, of the extent of influence of the field upon the perception of position.

[24] Particularly for the perception of body movement is it clear that the relation of the body to the field is important. Even the layman has many opportunities to obtain convincing evidence on this point. Traveling on a train, he has often had the illusory experience of feeling stationary when moving, or moving when stationary, during the passage of another train on an adjacent track. In the movies, the panoramic view passing rapidly across the screen has often created for him the illusion of body movement. In amusement centers, he has encountered devices such as the "haunted swing," in which a room is rotated on its horizontal axis about a stationary person seated in an open cubicle within it, creating the strong impression that he himself is moving .(The significance of the haunted-swing experience for problems of perception was recognized by Wood (7).) Turning to the more controlled conditions of the laboratory, we find in studies such as that of Dunker (3) additional evidence of illusory body movement induced by movement of the field. Kleint (4) has shown that whether the body is perceived as straight or tilted also depends on its relation to the field. He found that when placed in a room that was tilted backwards, *Ss* felt that they were tilted forwards.

Second, through the use of quantitative techniques, it proved the existence of marked individual differences in susceptibility to the influence of the field.

The new evidence of the extent of influence of the field was provided by performances of *Ss* who were very strongly affected by visual impressions. For such *Ss* the perceived position of the body tended to change with each change in the position of the field, and there was often considerable disparity between the true position of the body and its perceived position. Depending on its relation to the field, the body might be perceived as tilted when upright, upright when tilted, tilted to the left when objectively to the right, or tilted a great deal when only slightly tilted, and so on. To be perceived as straight the body had to be moved toward the axis of the field, and *Ss* were sometimes tilted as much as 20° or 30° when they reported themselves upright. These tilts are extremely large, considering that they apply not to an object in the environment, which provides only visual experiences, but to one's own body, which provides strong postural sensations as well.

The most dramatic proof of the importance of the field in perception of position was given by *Ss* who were completely unable to make themselves straight when placed in a tilted field. Such *Ss* tended to judge position primarily on the basis of how the body looked, but at the same time tried seriously to take account of pressure sensations. The dilemma was that when the body looked straight in relation to the field, it was objectively very tilted, and —even with some of the pressure sensations suppressed—felt tilted; whereas when the body felt proper, it was out of line with the field, so that it looked tilted. No position could be found in which the body both felt and looked straight. Although visual impressions seemed more valid to such *Ss*, they could not comfortably accept them because of the unexplained pressures. One *S* (Subject A, above) in the face of this conflict was not able to make herself straight in 50 minutes, after which time the effort was given up as hopeless. In cases where a decision was reached, it most often represented a compromise and not a real resolution of the conflict. Some of the experiences reported by such *Ss* in the course of trying to make themselves straight were strikingly at odds with what was really happening. Extreme difficulty in getting the body straight was often accompanied by real distress, and at times even led to illness. This is not surprising, since the difficulty pertained to the establishment of the person's own position in space.

Besides demonstrating the important influence of visual factors in the perception of position, this study, as mentioned above, contributed proof of the striking differences that exist among people in their degree of dependence upon visual factors in determining body position. The technique employed here was especially suited to the study of such differences. Ordinarily, the visual and postural determinants of position work in the same direction, so that their relative importance to the person cannot be determined. For example, perceiving one's body as tilted might be based primarily on an experience of pressure caused by the weight of the body against whatever was supporting it, or it might be based on seeing oneself at an angle with the field. The technique used here separated these two main determinants of position

by tilting the visual field while the direction of the gravitational vertical remained unchanged. This gave the person the alternative, in making his body erect, of aligning it with the vertical of the field, aligning it with the gravitational vertical where no pressure would be felt on either side, or establishing some compromise between the two. Furthermore, the degree to which he did achieve alignment with one of these alternative standards provided an index of his relative dependence on the two main determinants of position.

With this technique it was found that some people are little influenced by the appearance of the body, and seem instead to base their judgments primarily on sensations received from it. Such people are able to establish their true position with little error, regardless of the position of the field. Others are more strongly influenced by visual impressions, and base their judgments primarily on the appearance of the body in relation to the field. Bodily sensations may be discounted by these *Ss*, or obliterated entirely, or may simply remain in irreconcilable conflict with the stronger visual impressions. *Ss* for whom the last-mentioned is true show difficulty in reaching a decision, dissatisfaction with their judgments, and even inability to reach any decision. The individual differences in performance noted here again reflect—as did those observed in perception of the external upright—differences in perceptual experiences and not only in the manner of interpreting such experiences.

Not only have these wide individual differences in performance been demonstrated, but correlation of scores in different room-chair tests has indicated a relation between performances of the same individuals in different situations. Moreover, correlations obtained between room-adjustment and pointer-adjustment scores, and between room-adjustment and the dark-room situation scores, also indicate a general tendency toward consistency in the extent of a person's dependence on the visual field in his perception of both the external upright and the position of his body.[25] There are apparently characteristic ways of integrating visual and postural experiences, differing from person to person, which make for individual differences in perception under the same field conditions.

It was noted in previous reports that some of the errors made, particularly by poor *Ss*, might have been interpreted as the result of failure to think the problem through clearly. Many such seemingly "stupid" errors were also found in these experiments. For example, in some cases, when the room was tilted 35° left (or even 56° left) and the chair 22° left, the room was reported to be upright. Could not the *S* readily figure out that if the room was tilted even farther than his body it could not possibly be straight? There were many instances where *Ss* often judged the room to be upright when it was tilted 35° right (or even 56° right) and the chair was tilted 22° *left*. Could not the *S* quickly establish here that in spite of appearances the room could not be upright, because a 57° or 78° angle between the body and field would require that his body feel very much more tilted than it did? Another example is provided by Subject A, who could not figure out whether the front upright wall of the room was the floor or the ceiling. Should it not be a simple

[25] This problem of generality in mode of perception will be made the subject of a later paper.

matter to establish that a surface parallel to the body, which had not been tilted forward or back, could be neither ceiling nor floor? The same *S*, and others, also reported themselves to be standing on their heads when tilted only about 25° to the side. Again, it would seem an extremely easy matter to determine that the postural experiences did not at all correspond to the presumed position. Other *S*s, when the room was moved in 5° steps over a range of 70° while the chair remained stationary, reported the room to be upright in almost every one of the fourteen positions presented. This result is especially surprising, since the *S*s were permitted to observe each change and almost always perceived that movement had occurred. Is it not "unthinking" to believe that a room that is seen to move a number of times has nevertheless remained in about the same position? To cite a final example, *S*s on a number of occasions reported that both body and room were upright when there was a considerable angle between them. It seems particularly unintelligent not to realize that if the body and the room are not aligned one or both of them must be tilted. This list of "stupid" errors could be multiplied many times.

Two observations may be made at once in connection with these items. In the first place, each of the problems to be solved was so very simple that success could hardly depend on the possession of any great degree of intelligence. The very fact that serious errors were made in executing such very simple tasks suggests that intellectual factors alone were not at issue. The use of a college population as *S*s ought to have ensured considerably more intellectual capacity than was required for the tasks. In the second place, diagnosis of this behavior as stupid still leaves its basis unexplained. Granted that ineffective problem-solving behavior was shown, there remains the problem of identifying the block to more effective behavior.

For many of the examples cited, it has already been established in detail that the seemingly stupid behavior resulted from the particular way in which the *S* perceived the situation. To illustrate, we may consider the situation in which soms *S*s accepted the room as upright when it was tilted farther (35° L) than the tilted body (22°L). In some cases the room really appeared upright; and the body, which was to the right of the vertical of the room, was perceived as tilted to the *right*. If the body is perceived as tilted right, it can no longer be considered "stupid" to say that the room, which is to the left of it, is upright. The same visually dependent kind of orientation acounts for the report that the room was upright almost throughout as it was moved in 5° steps over a range of 70°. In each position the visual impression that the room was straight was so overwhelming that the movement noted became something of an artifact to be explained away. If a person's perception is known to be of this kind, "stupidity" ceases to be a very relevant dimension of the behavior.

Others of the examples cited above resulted from the confusion which at times occurs in such visually dependent people when they are unable to reconcile conflicting sensory experiences. The loss of bearings which led one *S* to see the front wall in the position of floor or ceiling exemplifies what can happen in such a state of confusion. The distress shown during these experiences, and the extent of the period over which the dilemma persisted, indicate that they

were not casual errors of intellectual origin.

Not all of the instances of "stupid" behavior cited can be explained entirely in terms of confusion or the special manner in which the *S* perceived certain aspects of the situation. In some instances the *S*'s account of his perception of the situation involved very real contradictions. Moreover, though most often very obvious, the contradiction, or some feature of the situation contributing to the contradiction, was simply "overlooked." This was true of *S*s who, with body 22° left and room 35° left, reported the room to be upright, though correctly perceiving the left tilt of the body. Another extreme example is provided by the performance of a particularly intelligent woman on a series of three trials in which she tried to make herself upright. The initial room-chair positions on these trials were (1) room 35° L, chair 22° R, (2) room 35° R, chair 22° L, (3) room 35° L, chair 22° R. At the outset of the first trial, she reported that the room was straight and she was tilted to the right. She had herself moved to 8° right, at which point she said she was straight. She also reported, however, that the room was still straight, although there remained a 43° angle between room and body. On the second and third trials the *S* performed in a similar fashion, each time reporting that both room and chair were straight when there was a considerable angle between them (25° and 43°, respectively). The discrepancy was glaringly obvious, and—one might have assumed—readily perceptible; yet, in spite of three opportunities to discern it, the *S* failed to "notice" the contradiction in which she was involved. The room looked "proper" to her; and at the same time she had found a position in which she herself felt "proper." Apparently the two experiences remained quite separate for her. To one observing her performance, it was evident that she was deeply involved in the problem and had a serious attitude towards it. The possibility that her error was simply a careless one is thus ruled out. That her behavior had a deep-seated basis was indicated by the difficulty the *E* encountered in making her aware of the error. It required a series of pointed questions, put after the third trial, to make her recognize that something was wrong; and the discovery clearly startled her. Even then, she was at a loss to account for the situation. She commented that there was "something crazy going on," and asked how it was possible for her to feel all right, and for the room to look all right, when they were not in line with each other.

Each of the situations investigated in earlier studies yielded similar instances, where glaring features of the situation went unnoticed and where even greater difficulty was encountered in bringing them to the *S*'s attention. A result obtained with several *S*s in the tilted-room experiment described in a previous report (2) may be cited. In that experiment, the task was to adjust a rod contained in the tilted room to the true upright. In one variation, the *S* was permitted to view the tilted room against the background of the upright laboratory while adjusting the rod. Several *S*s, for whom visual impressions formed the main basis of judgment, simply aligned the rod with the tilted room. Some of these, on questioning, stated that the tilted room was not straight with the outer laboratory, and that the rod, which was presumed to be upright, was in line

with the tilted room; yet these two insights were not connected to form the obvious conclusion that the rod could not in that case really be straight. It was necessary for the *E* to point this out specifically. What is even more amazing, in repeating the experiment several of these *S*s once again lined up the rod with the tilted room. The obvious character of the contradiction suggests that the difficulty was not an intellectual one; and the extreme persistence in "overlooking" it indicates that its detection was strongly blocked. The rod was within the field of the tilted room, and appeared straight to such *S*s only when aligned with the room. The room itself was in the field of the upright laboratory, and in relation to the laboratory was perceived as tilted. There were thus two perceptual systems involved, and these *S*s persisted in keeping them quite separate, in spite of the contradictions that resulted. A similar phenomenon was observed in the dark-room experiment previously reported (6), where the *S* had to straighten a luminous rod contained in a tilted luminous frame. Again, some *S*s simply lined up the rod with the tilted frame, and yet on questioning reported that the frame was not straight. It often took a great deal of discussion to make the *S* realize that the rod could not be straight when in line with the tilted frame; and, on repetition, the *S* performed in the same way.

These examples derived from different orientation situations have certain common features. A perceptually prominent aspect of the situation is "overlooked." The feature involved is so obvious that its neglect cannot be the result of a "lack of intelligence." Considerable resistance is encountered in bringing about an awareness of it. These facts together suggest that the process here may be analogous to what happens in real-life conflict situations, where emotional blocks prevent the perception of certain contradictory features of the situation, even when they are quite obvious. In each case cited, the *S* showed the kind of orientation in which visual impressions prove very influential, so that contradictory experiences are difficult to integrate. The procedures chosen to deal with these contradictions seem to have been in the direction of not perceiving them. The emotional involvement required to produce such blocks to perception was clearly present; for to be confused and uncertain about one's orientation can prove highly distressing.

Evidently—whether its explanation lies in a special manner of perceiving the situation, in confusion about one's bearings, or in emotional blocks to full, clear perception—the "stupid" behavior found in these orientation situations presents an extremely rich problem. An analysis of it helps reveal the basic nature of the perceptual processes involved, as well as the individual's characteristic way of handling perceptual data.

It was found in previously reported studies that knowledge was of negligible importance as a determinant of perception. Additional evidence on this point is provided by the present experiments. In one test, *S*s perceived a plumb line suspended in a tilted room as very much slanted, in the direction opposite to the tilt of the room. It was then explained to them that the plumb was actually hanging straight down, and that it appeared tilted because it was being viewed against the background of the tilted room. This understanding, however, did not at all alter for them the tilted appearance of the plumb line. In another

experiment, *Ss* who experienced the illusion of body movement when the room was rocked back and forth while the chair remained stationary were permitted to look toward the back of the room, so that by reference to the outer laboratory they could see that the room and not the chair was moving. But when they were required to look again toward the front of the room, so that they came once more under the influence of the moving field, the illusion of body movement returned. In another test, *Ss* who perceived the tilted room as upright were informed of its tilt and, in order that they might gauge its amount, permitted to look toward the back to see the angle it formed with the walls of the laboratory. When required to face the front of the room again, as a rule they perceived it as upright once more. These and similar findings confirm the earlier conclusion that introduction of knowledge about the "true" situation, which is at odds with the *S*'s perception of it, does not usually alter the perception itself.

V. SUMMARY

In order to permit an investigation of the factors involved in perception of the position of the body and of the field as a whole, and in order to investigate orientation under more natural conditions than those used in previous studies of this series, a new kind of apparatus was developed for this study. This apparatus consisted of a small room which could be tilted to left and right, within which was a chair which could also be tilted to left and right. Using this apparatus it was established, first of all, for a group of 45 *Ss*, that with movement of the room there was induced in most people a strong illusion of body movement. In another systematic series of tests carried out on a group of 54 *Ss*, the room and body were initially tilted, and the *S* was required to bring the one or the other to the upright position. In straightening the room there was a general tendency to underestimate its tilt, so that it was often perceived as upright even in very tilted positions. There were important individual differences in this regard, however, with some *Ss* tending to perceive the room as straight even at its initial tilt, and others, at the opposite extreme, proving able to bring the room to within a few degrees of the upright position. In straightening the body, it was found that the adjustment was based not only on postural experiences (eliminating pressures against the side) but also on visual impressions (having the body appear straight in relation to the surrounding field). In fact, it was established in a study using 46 *Ss* that in some cases, pressures of fairly large magnitude went undetected as a result of the visual impression that the body was upright. Important individual differences were again found in the perception of body position. Where some *Ss* were able to bring the body very close to the upright position, regardless of the tilt of the surrounding room, others tended to bring the body into alignment with the tilted field in making it straight. Correlations of the scores obtained under the various experimental conditions used indicate that there is some consistency in performance, more specifically, in the extent to which perception of the external upright and of body position are influenced by the immediate visual field. It has also been found that some *Ss* not only make large errors in their estimates of the position of the room and body, but they also experience great difficulty in making judgments. In some cases, *Ss* even became ill. Evidence is presented from a study of 45 *Ss* which indicates that the illness was caused by a loss of orientation. Finally, an analysis of some of the "stupid" errors made in the solution of these orientation tests indicates that their basis lies not in a "lack of intelligence" but in an individual's particular mode of perceiving the situation, or in the suppression of certain experiences under conditions of sensory conflict.

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